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A Classroom Teaching and Resource Guide in Conservation Education.

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In this teaching guide the natural and social sciences are integrated with an emphasis on conservation and ecology. The guide contains ten teaching units dealing with various physical and biological aspects of the environment. Unit one deals with the question of what is conservation. Unit two is concerned with the question of what is a natural resource. Units three through nine deal respectively with energy, minerals, soil, water, air, plants, and animals. Unit ten is entitled, "Human Resources." There are more activities and information in the guide than one teacher could use with a given class, leaving the decision as to which material to use with the teacher. Each unit is self contained and may be used independently of the others. A bibliography of learning materials is included with each unit and a bibliography of free and inexpensive materials appends the guide. This work was prepared under an ESEA Title III contract. (BC)

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A
CLASSROOM
TEACHING AND RESOURCE
GUIDE
IN
CONSERVATION EDUCATION

Elementary and Secondary Education Act of 1965
Title III

August 15, 1968

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FOREWARD

NATUREALM is an approach to education in which the natural and social sciences are integrated with an emphasis on conservation and ecology. The materials presented here are the combined efforts of many educators who realize the importance of creating an awareness and an interest in the citizens of this country to the problems involving natural resources.

There are more activities and information presented in the guide than any one teacher would use with a class. The teacher will have to choose the material that best fits the needs of a specific class.

The guide has been developed so that each unit is self-contained; that is, one unit may be used independently of the other units, or all of the units may be used in sequence to present an integrated course in conservation.

Each unit contains basic background information that will prove helpful in developing the concepts of the unit. However, some of the concepts mentioned in the outline are not covered in the background material. The teacher's previous training and experience will dictate to what extent he will find the bibliography of each unit helpful. The outline contains the major topics that should be presented for a more complete understanding of that particular resource. The staff has endeavored to present the material in a logical, systematic, and integrated manner.

The compilation of learning activities illustrates many activities that can be done by the student and teacher to further enhance the desired concepts.

The bibliography lists many books and pamphlets that present additional background in the various areas covered by the outline.

Sources of free and inexpensive materials (films, books, and pamphlets) are listed at the end of the guide.

In no way is this guide to be considered as a final product. It is merely a starting point to introduce the study of conservation to the present-day student. By continuous evaluation, revision, and wise selection of material by the teacher to use areas of the curriculum that meet his particular needs, NATUREALM will become an initial force in expanding the interest and knowledge of our citizens in conservation.

PHILOSOPHY

Natural resources have been the prime motivating factors of all civilizations. A nation's might and progress are closely related to its natural resource supply and the ability to harvest them. The wise use of these resources can raise a nation to the epitome of world power and high standards of living, but the misuse of these same resources can plunge a nation and its people into the depths of despair.

Therefore, a close relationship exists between man and his natural resources. It is imperative that man becomes aware of the importance of his natural resources; he learns the true meaning of conservation; he learns how to recognize problems that threaten the national heritage of the world; he learns how to solve the problems already created in his environment by past neglect and thoughtless actions and how to prevent similar problems from occurring again; he learns how to use his increasing leisure time wisely; and he learns that the cause for most of these problems is primarily ecological or due to his own presence and interaction in the natural environment.

Since these problems are man-made, it is the thought of NATUREALM that the problems already created can be solved and future problems can be prevented by making man acutely aware of his surroundings and the tremendous influence he exerts on the environment.

NATUREALM is a new approach, based on conservation and ecology, to teaching science. It does not advocate the elimination of textbooks, classrooms, etc. but wishes to supplement and complement the standard methods of teaching by making more use of the outdoors as an educational tool.

What can best be learned inside the classroom should be learned there; what can best be learned in the outdoors through direct experience, dealing with native materials and life situations, should be learned there.

NATUREALM is a program designed to change the concept of conservation from one of teaching about conservation to one of teaching living conservation by employing the unifying factor of nature--ecology.

OBJECTIVES

1. To develop an awareness of man's tremendous influence on the natural environment and an ability to recognize natural resource problems and issues.
2. To develop an awareness and an interest in the outdoors and natural resources.
3. To develop an awareness that the environment is constantly changing (dynamic equilibrium).
4. To develop an appreciation of the natural environment as a resource for the wise use of our increasing leisure time.
5. To develop an appreciation of the natural environment as a means of earning a livelihood.
6. To develop an ability to see the relationship between cause and effect between the environment and everyday living.
7. To develop the ability to reason from observed facts to the level of principles and concepts. *
8. To provide educational experiences which bridge the gap between the classroom and the natural environment. *
9. To develop a better understanding of the "problem—solving" method.
10. To develop an ability to observe critically and record natural phenomena using all of the senses.
11. To develop an understanding of conservation which is envisioned as the wise use of natural resources for the most good for the most people.
12. To develop and encourage an attitude of appreciation as well as a moral and civic responsibility for the preservation and conservation of our natural resources. *
13. To provide a better understanding of the inter-relationships fundamental to life. *

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*Adapted from Rose Tree Media Outdoor Education Project.

CONSERVATION

BACKGROUND INFORMATION

Conservation means different things to different people. As a result, it is defined in many ways. A few definitions are:

1. Conservation is the wise use of our natural resources so that the greatest number of people will benefit for the longest possible time. (Theodore Roosevelt)

2. Conservation is the maintenance of "a state of harmony between man and the land". (Aldo Leopold)

3. Conservation is the preservation, restoration, and management of our resources for the benefit of our own generation with due consideration for those yet to come.

4. Conservation is the wise use, intelligent development, and efficient management of our natural resources.

5. Conservation consists of equating the use of natural resources with the varying demands of population so that resource supplies will not become exhausted before adequate supplies of equally useful resources are either discovered, invented, or otherwise reproduced. (Charles Lively)

6. "Conservation implies both the development and the protection of resources, the one as much as the other . . . ." (Gifford Pinchot)

Conservation is an applied science--the science of making men and nature cooperate. It is the study of the delicate balance between man and his environment. Conservation programs, through the application of science and technology, are designed to maintain that balance in the interests of humanity. It recognizes that economic life of our communities depends upon how well and how wisely we use our water, soil, air, forests, wildlife, minerals, and people.

The difficult problems arise in those cases in which the preservationists and the industrialists disagree as to the best use of a resource. To achieve a compromise between these two groups, the "multiple use" concept was devised. "Multiple use" means to plan and use a resource in as many different ways as possible. However, this does not solve the problem because some uses of resources are incompatible with other uses, even though all uses may be in line with approved conservation practices. For example, a dam built for flood control cannot be used for recreation as well as a dam built for recreation because the flood control dam should be maintained at a low water level while a recreation dam should be maintained at a high water level.

Conservation is or should be of interest to every citizen in the world. In the United States, two hundred million people live on 3,548,974 square miles of the earth's surface. This represents only six per cent of the world's population living on seven per cent of the world's available area. We have one of the highest standards of living in the world. For example, a recent survey showed that we owned sixty per cent of all the automobiles in the world, fifty-two per cent of all the telephones in the world, forty-eight per cent of all the radio sets in the world, and twenty-nine per cent of all the railroad mileage in the world. We consumed forty per cent of the world's annual lumber production, thirty-four per cent of the world's electric power, thirty-three per cent of the world's petroleum production, twenty-four per cent of the world's coal production, and twenty-four per cent of the world's rubber production.

Numerous other examples of our high standard of living could be given. The idea to remember is that our standard of living is closely related with natural resources and how we care for them. Consequently, if we are to maintain and improve our standard of living, conservation is everybody's problem from farmer to housewife.

To understand how we achieved this standard of living, consider the following example. Assume that Mr. Jones has just inherited a million dollars and that Mr. Smith, his neighbor, has inherited a thousand dollars. Which of these two men might you expect to have the higher standard of living? Mr. Jones, of course, even though he is no more industrious nor more intelligent than Mr. Smith.

Twenty years later which man will have the higher standard of living. Obviously this depends upon several factors, one of which is how wisely Mr. Jones manages his inheritance. He might squander his fortune on riotous living--giving him a temporarily high standard of living--but later he may not have adequate funds to meet his fundamental needs. It is also possible that he might invest his money carefully, spending only the interest from the investment. In such a case, twenty years later, he still has his original inheritance and is assured of a comfortable annual income as long as he needs it.

In the above example, let us substitute nations for men. As a nation, we have received a rich inheritance of natural resources, such as: fertile soil, valuable minerals, clean streams, extensive forests, abundant wildlife, and delightful scenic areas. Any nation receiving such an inheritance is assured a continuing high standard of living if the natural resources are properly used. We have several choices. We can squander our inheritance on a temporarily high standard of living and end up broke sometime in the near future, or we can use it wisely, thus having a comfortable standard of living as far into the future as we can see. The first choice we call exploitation; the second, conservation.

Conservation was not always in the forefront. In fact, not enough time, money, and thought is given to conservation today. In pioneer America it was very difficult to persuade people to take any interest in conserving the country's natural resources. The attitude of the early American colonist toward the use of natural resources was, to a large extent, that such resources constituted a barrier to the establishment of home and community. Their thought was that there were so many trees, streams, and other resources that we would never face a shortage in these commodities so why worry about them. We can now see the result of this type of thinking. Witness the dust storms in the Midwest, the passenger pigeon, the buffalo, deserted farming areas; the list is endless. The sad part is that some of us have not learned from the past and still think there is no need for conservation.

The movement for conservation of natural resources, as we in the United States think of it today, began to take form in this country in the nineteenth century because of the concern for our rapidly disappearing forests.

The word conservation did not gain a firm place in the American vocabulary until 1907 when Overton Price used the word, "conservancies", to describe government forests in India. Gifford Pinchot, often called the founder of American conservation, liked the term and used it to describe his concept of "the use of the earth for the good of man". Pinchot had a tendency toward the extraction aspects of conservation and considered wilderness areas a form of waste. However, he was the first man to use government powers to promote management of basic resources.

Pinchot framed most of the ideas which became Theodore Roosevelt's conservation program including such projects as:

1. The White House Conference on Conservation in 1908.
2. The Inland Waterways Commission Study.
3. The landmark report of the International Conservation Commission in 1909.

Only two times in this century has conservation been a major preoccupation of our people and government.

1. In the early 1900's which culminated in the Governor's Conference of 1908.
2. In the rebound from the depression in 1933-36 (Civil Conservation Corps).

Over the years, conservation has developed along two separate lines. One faction was concerned with the renewable resources and the other group with the non-renewable resources.

In recent years, the trend is toward resource conservation in which the relationship of all resources is considered before any action is taken. This has resulted in the following two discernible trends:

1. A shift from emphasis on preservation of resources to emphasis upon development of resources to maximize benefits from their use
2. A shift from emphasis on single purpose development to multi-purpose concepts

Much of the conservation history to date has been much talk and quick action only when threats to the public health are imminent.

Conservation is gradually becoming a part of the American way of life. More and more people are coming to accept the principles of conservation and to govern their lives accordingly.

Effective conservation requires an attitude of appreciation toward natural resources--toward their value and the value of their wise use for one's self, for one's fellow man, and for future generations. We should feel an obligation to generations yet unborn to leave to them this earth as liberally furnished with resources as when we ourselves inherited it.

The physical strength of any nation is based upon the wise use and perpetuation of its natural resources. The illusion that America is a land of plenty--that its wealth of soil, water, wildlife, minerals, and other natural resources is inexhaustible--is a happy one. Unfortunately, many people still hold this belief today despite the fact that some of America's resources have already been reduced to the danger level.

What the future holds largely depends on the success of today's conservation laws and practices. Regardless of the brilliance of our scientists, the wisdom of our statesmen, the ingenuity of our industrialists, and the skill of our workmen, our country cannot continue in its role as a leading nation with its soil exhausted, its forests leveled, and its wildlife destroyed. Once the resources are depleted, and the water and air are polluted; we, as a species, will be extinct also.

OUTLINE OF CONTENT MATERIAL

I. Definition of Conservation

II. Conservation in Relation to
  A. High standard of living
  B. Strength of a nation.
    1. Economic.
    2. Military.
  C. Recreation.
  D. Esthetic values.
  E. Ecology.

III. Importance of Conservation to
  A. Governments.
  B. Communities.
  C. Individuals.

IV. History of Conservation in the United States

V. Basic Conservation Concepts
  A. People need to understand that man is only part of the natural world in which there are many valuable materials that he has learned to utilize for human sustenance and for human betterment. Man's economic, social, and political welfare is largely dependent upon the manner and extent to which he utilizes and manages this natural wealth.
  B. Man's understanding of diminishing resources is limited by the brevity of the individual human life. As a result, man frequently fails to recognize the gradual disintergration and wasting away of certain of our more important resources.
  C. Young people need help in establishing their own position in the calendar of the earth's history. They need help in understanding the damages which result from poor conservation techniques.
  D. The most distinctive characteristic of both the living and the inanimate world is change.
  E. To show the importance of the ecological aspects of conservation, it is desirable that people explore the close relationships between soil, water, plant cover, and animal life, including man.
  F. The world's rapidly increasing population will continue to levy an ever greater demand upon natural resources. This may cause overuse or increased misuse of resources; but through technological advances, enterprising populations may be able to maintain or even raise modern

standards of living without threatening the depletion of basic resources.

G. People must become alert to the problems arising from resource use. It is likewise essential that they become acquainted with the activities of private, state, and national agencies that are concerned with the control and management of those resources so that they can help and improve the work of those agencies.

VI. Conservation Pledge

> I give my pledge as an American to save and
> faithfully to defend from waste the natural resources
> of my country--its soils and minerals, its forests,
> waters, and wildlife.

LEARNING ACTIVITIES AND MATERIALS

I. Learning Activities
  A. Demonstrations.
    1. Borrow or make a farm level and practice running contour lines on the school grounds or a nearby field. How does this contribute to good conservation?
    2. Illustrate, by using models, the various ways in which land may be brought under cultivation. Are these land policies designed to get the greatest good over the longest period of time?
    3. Establish or develop an area in or near the school grounds and manage the area using practices consistent with good conservation procedures.
  B. Field trips.
    1. To any outdoor area to study conservation practices that are being used or should be used.
    2. To a place of beauty to point out the features or combination of features which provide the beauty or uniqueness of the area.
    3. To a museum and study various displays. Then, choose five or six and discuss the significance, if any, of each.
  C. Discussion.
    1. What is conservation?
    2. Who should be interested in conservation? Why?
    3. What are the advantages of a planning commission in regard to land usage?
    4. What can you do about conservation?
    5. Why are governments interested in conservation?
    6. How is science being used to help solve the conservation problem?
    7. How is the area in which you live changing and to what is the change attributable? Would conservation practices have affected the outcome?
    8. What private and governmental agencies are contributing to conservation practices?
    9. Discuss "wise use" as it is used in the definition of conservation in relation to natural resources.
    10. How does urban expansion affect the conservation and ecology of an area?
    11. Is creation of a state park in line with conservation principles?
  D. Bulletin board displays.
    1. A display showing the interdependence of various living and non-living materials on earth.
    2. Pictures of animals and birds that have become extinct or are near extinction because of poor conservation practices.

E. Student activities and projects.

1. Using the following checklist, determine conservation trouble areas in your community and suggest how the problems might be prevented or corrected.

	No	Potential Problem	Yes Major Degree	Yes Moderate Degree	Not Revelant
a. Refuse and garbage disposal					
b. Junk car disposal					
c. Air pollution					
d. Water pollution					
e. Soil pollution					
f. Littering					
g. Overhead power lines					
h. Outdoor advertising					
i. Preservation and development of historic landmarks					
j. Substandard residential area					
k. Unsightly commercial areas or strips					
l. Unsightly or dilapidated buildings					
m. Unregulated suburban developments					
n. Inadequate or unsightly roads or highways					
o. Abandoned open pits					
p. Soil erosion					
q. Preservation and development of waterways and waterfronts; include canals and reservoirs as well as rivers, streams, and lakes					
r. Landscaping along highways, roads, public housing, and other government property and semi-public land (as parking lots)					
s. Unsightly large areas of vacant property (as abandoned military, urban renewal, or highway demolition, etc.					
t. Excessive deforestation					
u. Others (list below)					

2. Describe the relationship between activities in the community and its economy and resources.
3. Suppose you were running for a state or national legislative office. List the planks which might be included in your platform for the elimination of water and air pollution.
4. Suggest ways of improving our attitudes toward the conservation of natural resources.
5. Collect pictures, articles, plants, etc. for demonstrations in a "conservation corner" or scrapbook.
6. Organize a conservation club.
7. Assume that you are a delegate from your county to a conservation congress. What proposals would you make at the congress which would tend to improve the use of natural resources?
8. Hold a panel discussion centered on the topic, "What the conservation program of our community should include."
9. Compile a list of activities that you could do at home to help conserve natural resources.
10. Write a conservator's creed and compare it with other creeds and pledges composed by conservation organizations.
11. Make a "conservation corner"--a corner of the room to display any material pertaining to conservation.

II. Learning Materials
  A. Audio-visual materials.
    1. See list of sources at the end of the guide.
  B. Books and pamphlets.
    1. Carson, Rachel, Silent Spring, Houghton Mifflin Company, Boston, 1962.
    2. Concepts of Conservation: A Guide to Discussion of Some Fundamental Problems, The Conservation Foundation, 1250 Connecticut Avenue, N. W., Washington, D. C.
    3. Conservation in the People's Hands, published by American Association of School Administrators, 1964.
    4. Cooley, Richard H., Politics and Conservation, Harper & Row.
    5. Coyle, D. C., Conservation, An American Story of Conflict and Accomplishment, Rutgers University Press, 1957.
    6. Dasmann, Raymond F., Environmental Conservation, John Wiley & Sons, Inc.
    7. Farness, S., "Better Living Through Conservation Planning", The Population Crisis and the Use of World Resources, Indiana University Press, 1964.
    8. Harrison, William C., Conservation, The Challenge of Reclaiming Our Plundered Land, Juhan Messner, Inc., New York, 1963.
    9. Hartley, Sir Harold, "Man and Nature", American Scientist, Vol. 53,

10. Halfman, Elizabeth S., Land, People, and History, David McKay Company, New York, 1962.
11. Herfindahl, O. C., "What is Conservation?", Minerals Economics, Resources for the Future, Inc., Washington, D. C., 1961.
12. Hubbard, Alice Harvey, This Land of Ours: Community and Conservation Projects for Citizens, The MacMillan Company, New York, 1960.
13. Jarett, H., Perspectives on Conservation, Essays on America's Natural Resources, The Johns Hopkins Press, 1958.
14. Joy, Charles R., Race Between Food and People: The Challenge of a Hungry World, Coward-McCann, Inc., New York, 1961.
15. Munzer, Martha E. and Brandwein, Paul E., Teaching Science Through Conservation, McGraw-Hill Book Company, Inc., 1960.
16. Osborn, Ben, Introduction to the Outdoors, Audubon Naturalist Society of the Central Atlantic States, Inc., Washington, D. C., 1960.
17. Parson, Ruben L., Conserving American Resources, 2nd Edition, Prentice-Hall, Inc., New Jersey, 1964.
18. Pettit, Ted S., The Web of Nature, Doubleday & Company, New York, 1960.
19. "Pollution of the Environment", excerpts from a talk by Roger Revelle, American Scientist, Vol. 54, June, 1966.
20. Quest for Quality, Vol. 8, Department of the Interior, Conservation Yearbook, 1965.
21. Smith, F. C., The First Book of Conservation, Franklin Watts, Inc., New York.
22. Storer, John H., The Web of Life, Devin Adair.
23. Tunnard, Christopher, and Pashkarev, Man-made America: Chaos or Control, Yale University Press, New Haven, 1963.
24. Udall, S. L., The Quiet Crisis, Holt, Rinehart & Winston, 1963.

NATURAL RESOURCES

BACKGROUND INFORMATION

According to Greek mythology, Antaeus, a giant of Libia, was the son of Poseidon, god of the sea, and Terra, goddess of the earth. As a wrestler, Antaeus was long invincible; everytime he was thrown down, he arose with renewed strength because when he touched the earth, his mother, his strength was instantly renewed. When he lost touch with the earth, his strength dwindled and he was soon overcome. Hercules was able to win a wrestling match with Antaeus by holding him aloft in the air until his strength was gone.

There is a moral to this story that is worth noting. Modern civilization is able to maintain its strength only so long as it maintains contact with the earth from whence comes its strength. City dwellers are prone to lose sight of this fundamental fact of life since many of them are far removed from the countryside that supplies the raw materials that make city life possible.

What is this strength that is supplied by the earth? What are the raw materials that make our present civilization possible? Collectively we refer to them as natural resources. Natural resources can be simply defined as materials supplied by nature.

Natural resources are the natural wealth of a country and consist of human resources, land, air, water, minerals, forests, soils, vegetation, wildlife, and marine life. The concept, "natural resources", is largely derived from our own society's ceaseless attempts to find new and more intensive uses for the raw materials of nature and is, to a great extent, a creation of man. Perhaps our chief resource is man's intelligence.

When we call something a resource, we have classified it as a means, an instrument, to achieve our own ends. This is primarily an economic attitude; and, unfortunately, we are geared primarily for economic decision making concerning resources.

As population, urbanization, industrialization, and leisure time increase in this country, the general public is becoming more aware of such resources as air, wildlife, wilderness areas, and recreational land.

In the United States, we are beginning to recognize factors other than economic in our resource planning. These factors are simultaneously conflicting and complementary and require continous coordination. Some of these factors are:

1. Resource planning for economic output.
2. Regional planning for urban habitat.
3. Facility planning for technical efficiency.
4. Ecological planning for biotic fitness.
5. Social institution planning for implementation.

6. Planning for strong national defense.

Today, in the United States only ten per cent of our labor force is engaged in providing raw materials while the other ninety per cent are employed in other areas of endeavor, all of which rest on a base of natural resources. While the number employed in resource industries has declined in recent years, the volume of resource production and consumption has been climbing steadily. For example, the consumption of most fuels and minerals in this country alone has been greater since the beginning of World War I than total world consumption for all the preceding centuries.

In 1960, the United States used eighty million tons of metals, forty-five quadrillion B. T. U. 's of energy (equal to one and three-fourth billion tons of coal or eight billion barrels of oil), eleven and one-half billion cubic feet of timber, twenty-one billion dollars of farm products, and eighty-five billion gallons of fresh water per day.

Natural resources are usually divided into two classes--renewable and non-renewable. The classification can be extended to include inexhaustible and the yet-to-be discovered resources.

Renewable resources are those which can be replenished when properly managed. This includes such things as soil, water, forests, and wildlife (see the outline for more examples). These resources are renewable in that they can be used for a variety of purposes and if properly treated, be used over and over. For example, soil can be used to produce crops year after year, and if properly managed, its condition can actually be improved beyond its original status.

Resources that can be used only once are referred to as non-renewable. Minerals including fuels, such as coal, petroleum, and natural gas, are examples of this type of resource. When this type of resource is used, it is gone forever. At least, it cannot be replaced in the foreseeable future. Conservation of these resources consists of carefully budgeting the available supply, use of substitutes when feasible, and reuse of scrap metals when possible.

Resources that seem so abundant at present that the supply appears to be unlimited are called inexhaustible. In regard to our history of managing resources, it is wise to point out the words "seem" and "appear" in the definition of inexhaustible resources. The oceans, sun, solar energy, winds, and atomic energy (fusion) appear to be examples of inexhaustible resources. However, if we do not manage our environment any better in the future than we do now, this classification may have to be changed. Air and water pollution as they are now occurring could affect these resources and cause unpredictable changes in the future.

If science and technology continue to progress at the present rate, new resources and new uses and substitutes for old resources will undoubtedly be discovered. These yet-to-be discovered resources and new uses make up the last category of natural resources.

To date, men have learned that soil has depth, can be classified according to qualities and physical properties, possesses complex characteristics--each influencing the other--and that soil management is a combination of practices fitted uniquely to different kinds of soils. Nearly two million farmers and ranchers plan the use of their soil and water resources through approximately three thousand soil conservation districts.

Land use determines the amount and quality of food, timber, and fiber crops. It affects the water supply, condition of the air, space available for recreation, and patterns of urban development.

Urban expansion, road building, and development of recreational areas is taking about a million acres a year from the two thousand two hundred and seventy-one million acres of total land area in the United States. At the present time, approximately eighty-one per cent of the total is devoted to crops, grazing, and related uses. The other nineteen per cent is used for cities, highways, railroads, recreational lands, and other similar uses.

At the time of settlement, the forests of the United States were unequalled anywhere in the world's temperate zone. The forest area was estimated to exceed eight hundred million acres comprised of more than one hundred timber species. The rapid destruction of virgin forest tracts helped shape public opinion and make possible establishment of the present system of national forests and to introduce the principle of sustained yield in forestry management.

In 1958, the annual timber growth on the five hundred and twenty-nine million acres of commercial and two hundred and fifty-five million acres of non-commercial forest land was estimated to be 15.2 billion cubic feet; the estimated harvest for the same year was 20.8 billion cubic feet. Deterioration of quality and low yield is an increasing problem. The output of forest lands will have to double to meet the anticipated demands of the year 2000.

Water is an indispensable resource and one of the country's major resource problems. In most areas of the United States, due to uneven distribution and supply, some form of water management is necessary to maintain a constant supply. Agriculture and industry make the greatest demands on this supply.

Most water shortages occur not from absolute lack of water, but from failure of people to plan for optimum use of available supplies. Maintaining an adequate water supply for future needs is perhaps the major conservation problem confronting people today. They must be prepared for the eventual cost of such a program and change their thinking from water quantity to water quality control.

A wilderness area is one totally undisturbed by economic development or other cultured innovations. Very little of the United States remains in its original state. It is the feeling of an increasing number of people that some of the virgin areas should be preserved in their natural state, regardless of the economic possibilities.

Wholesale destruction that led to extinction of several species in the United States created a climate of opinion that led to the formation of organizations to preserve wildlife. This movement resulted in the first federal reservation for wildlife in Florida in 1903. In 1961, the number of federal game preserves numbered two hundred and eighty-four and encompassed 28.5 million acres under the control of the United States Department of the Interior. In addition, there are millions of other acres under the control of state and private ownership operated as game preserves.

The loss of a single species may appear unimportant, but it is often the beginning of a chain reaction that eventually affects many species.

Fishing resources of fresh and salt water have not been fully utilized by people in the United States because we have never had a shortage of high protein foods. The annual consumption of fish in the United States is only eleven pounds/capita compared with fifty pounds or more in many other nations.

Fish and shellfish resources were considered unlimited for many years. However, depletion of cod in the Atlantic, oysters and blue crabs in the Chesapeake Bay, and the salmon in the Pacific finally convinced fishermen of the need for conservation measures.

There are more than three hundred species of "useful" fish and shellfish known, but less than twelve account for sixty per cent of North America's catch. This reservoir of food will have to be utilized in future years to alleviate the food problem. At present, sport fishing has a greater impact upon American economy than the commercial fishing industry--not in terms of total catch, but in terms of money spent for equipment, supplies, boats, and traveling. In 1960, twenty-five million fishermen spent three billion dollars in pursuing this sport.

The culture of this age is accented by the use of power machines and minerals. Most mineral resources are classed as non-renewable because the deposits are formed over very long periods of time.

The ratio of the price of minerals to cost of finished mineral products increased only twenty-three per cent between 1900 and 1957. The real problem for the future is to keep the price of minerals at a level which people can afford. With the increasing United States dependence on foreign sources of mineral supply and with increasing competition from other nations for the same world supply, the necessity for general public policy pertaining to conservation and use of minerals becomes greater.

The demand for energy is likely to be about three times as high in the year 2000 as it is now. New sources of energy, such as: nuclear, oil and gas refined from coal, offshore gas and oil, and oil shale development, should help to hold down rising costs.

Technology has been termed the "inexhaustible resource". The rationale of this idea of infinite resources rests on the assumption that utilization of resources under certain conditions stimulate techniques which will make more resources available in the future. However, the limiting factor of any resource use may come when we are faced with diminishing returns for our investment, or we pollute the environment beyond survival.

OUTLINE OF CONTENT MATERIAL

I. Definition

II. Use of Resources

III. Categories
  A. Renewable resources.
    1. Examples of materials.
      a. Soil.
      b. Water.
      c. Forests.
      d. Wildlife.
      e. Grasslands.
      f. Plant communities.
      g. Wilderness areas.
    2. Examples of energy.
      a. Water power.
      b. Tides.
  B. Non-renewable resources.
    1. Examples of materials.
      a. Minerals.
      b. Chemicals.
    2. Examples of energy.
      a. Fossil fuels.
      b. Atomic energy (fission).
  C. Inexhaustible resources.
    1. Examples of materials.
      a. Oceans.
      b. Sun.
      c. Air.
    2. Examples of energy.
      a. Solar.
      b. Winds.
      c. Atomic (fusion).
  D. New and yet-to-be discovered resources.

IV. Status of Some Resource Categories
  A. Soil and land.
  B. Forests.
  C. Water.
  D. Wilderness areas.

E. Wildlife.
F. Fisheries.
G. Minerals.
H. Shorelines.
I. Energy.
J. Technology.

V. United States Requirements of Selected Natural Resources and Resource Products - 1960 and Projected 2000*

	1960	2000
Cropland including pastures (million acres)	447	476
Wheat (million bushels)	1,110	1,385
Cotton (billion pounds)	7	16
Timber (billion cubic feet)	11	32
Fresh water, withdrawal depletion (billion gallons/day)	84	149
Oil (billion barrels)	3.2	10
Coal (million tons)	436	718
Natural gas (trillion cubic feet)	13.3	34.9
Iron ore (million tons)	131	341
Aluminum, primary (million tons)	2.1	13.3
Copper, primary (million tons)	1.7	4.5
Nuclear power (million kilowatt-hours)	--------	2,400

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* Fisher, J. L., Future Environments of North America, p. 273, 1966, originally from Landsberg, Fischman, and Fisher, Resources in America's Future, 1963.

LEARNING ACTIVITIES AND MATERIALS

I. Learning Activities
  A. Demonstrations.
    1. Burn a piece of coal to produce energy and to illustrate the meaning of a non-renewable resource.
    2. Plant various species of plants in different types of soil (sand, clay, etc.) to illustrate the relationships of one resource to another.
    3. Prepare examples of natural resources found in your area.
  B. Field trips.
    1. To a managed lumbering area to illustrate a renewable resource.
    2. To an electric generating plant using coal or oil to illustrate the use of a non-renewable resource.
    3. To any outdoor area to see the relationship of non-renewable resources and renewable resources.
       Example: Note the change in species that occur in a wooded area before and after the trees are harvested.
    4. Follow a stream for several miles and note the different uses made of the water (a renewable resource).
    5. Visit a managed watershed and study the inter-relationships of all the natural resources in the area.
  C. Discussion.
    1. How would the misuse or removal of a natural resource from your community affect the other resources? How would it affect you?
    2. Is management of natural resources "big" business? Give examples to support your answer.
    3. How do you disrupt natural cycles by burning weeds, leaves, and grass at home?
    4. What will happen to the United States as a world power if we do not start using better conservation practices?
    5. Who owns the natural resources?
  D. Bulletin board displays.
    1. Make a resource cycle. Show the inter-relationship of all resources.
    2. Show the major resources of your community and how they affect the economy, recreation, and health of the people of the community.
  E. Student activities and projects.
    1. How many different natural resources are found in your community?
    2. Start a collection of natural resources of your area. Classify them according to renewable or non-renewable resources.
    3. Is your community managing these resources properly? If not, outline a list of possible conservation practices that could be employed.

4. List all the natural resources that you use at home. Determine if any substitutes could be used for these resources.
5. What could you do to help conserve natural resources?
6. Write a paper concerning the decline and fall of ancient civilizations. Did natural resources play a role in their decline?

II. Learning Materials

A. Audio-visual materials.

1. See list of sources at the end of the guide.

B. Books and pamphlets.

1. Allee, D., "American Agriculture--Its Resource Issues for the Coming Years", Daedalus, pp. 1071-1081, Fall, 1967.
2. Allen, Shirley W., Conserving Natural Resources, McGraw-Hill, New York.
3. Bates, Mason, The Nature of Natural History, Charles Scribner's Sons, New York, 1961.
4. Boylko, H. (editor), Science and the Future of Mankind, Dr. W. Junk Publishers, The Hague, 1964.
5. Callison, Charles H., America's Natural Resources, The Ronald Press Company, New York, 1957.
6. Curtis, H. A., "The Barrier of Cost", pp. 79-85, Perspectives on Conservation: Essays on America's Natural Resources, H. Jarrett (editor), The Johns Hopkins Press, 1958.
7. Duhcan, C., "Resource Utilization and the Conservation Concept", A Bobbs-Merrill reprint from Economic Geography, Vol. 38, No. 2, April, 1962.
8. Fisher, J. L., "Natural Resources and Economic Developments: The Web of Events, Policies, and Policy Objectives", pp. 261-276, Future Environments of North America, The Natural History Press, 1966.
9. Gabrielson, Ira N., Wildlife Conservation, 2nd Edition, The MacMillan Company, New York, 1963.
10. Griffiths, J. C., "Exploration for Natural Resources", Operations Research, Vol. 14, No. 2, March-April, 1966.
11. Handbook for Teaching of Conservation and Resource Use, Natural Association of Biology Teachers, Washington, D. C., 1958.
12. Hill, Wilhelmina, The Three R's and Resources, National Wildlife Federation, Washington, D. C., 1959.
13. Hunkers, H. L. (editor), Erich W. Zimmerman's Introduction to World Resources, Harper & Row, 1964.
14. Landsberg, H., Natural Resources for United States Growth, The Johns Hopkins Press, 1964.
15. Landsberg, H., "The United States Resource Outlook: Quantity and Quality", Daedalus, pp. 1034-1057, Fall, 1967.

16. Maslach, G. J., "The Reorganization of Education Resources", Daedalus, pp. 1200-1209, Fall, 1967.

17. Nolan, T. B., "The Inexhaustible Resource of Technology", pp. 49-68, Perspective on Conservation: Essays on America's Natural Resources, The Johns Hopkins Press, 1958.

18. Pennsylvania Teaching Guide to Natural Resources Conservation, Curriculum Service Series No. 7, Department of Public Instruction, Harrisburg, Pennsylvania, 1962.

19. Prien, C. H., "The Future of United States Oil Shale Resources", Geoscience News, March-April, 1968.

20. Quest for Quality, Conservation Yearbook, United States Department of the Interior, 1965, (also 1966 and 1967 Yearbook).

21. Revelle, R., "Outdoor Recreation in a Hyper-productive Society", Daedalus, pp. 1172-1191, Fall, 1967.

22. Rogers, J. J. W. and Adams, J. A. S., "Man in Geologic Perspective", Chapter 16, Fundamentals of Geology, Harper & Row, 1966.

23. Spoehr, A., "Cultural Differences in the Interpretation of Natural Resources", A Bobbs-Merril report from Man's Role in Changing the Face of the Earth, The University of Chicago Press, 1956.

24. Wollman, N., "The New Economics of Resources", Daedalus, pp. 1099-1114, Fall, 1967.

ENERGY

BACKGROUND INFORMATION

Man's progress from non-machine levels of culture to machine levels of culture has been closely correlated with an increased use of energy. In fact, some historians claim that a nation's progress can be measured by its consumption of energy. Increased use of energy leads to increased production; increased production leads to more leisure time; more leisure time gives man an opportunity to invent and use more labor-saving devices.

Although not a true classification, it is convenient to divide energy into two categories--potential and kinetic energy. Potential energy (stored) may be converted into kinetic (energy of moving objects) and vice versa. The pendulum is a good example of this. At the peak of its swing, all of the energy is potential and at the lowest point of its arc, all of the energy is kinetic. Halfway between these two points, the energy is fifty per cent kinetic and fifty per cent potential.

Potential energy may be due to certain properties of the material itself. A piece of wood has potential energy because it has the ability to undergo rapid oxidation and produce energy (heat and light). Other materials may have potential energy as a result of their position, such as a rock at the top of a cliff. The rock will fall and release energy, but the force of gravity imparts the energy to the rock.

Kinetic energy is energy in motion or energy that is doing work at that precise moment, for example, a flowing stream.

Chemical energy, in this unit, refers to any energy released as a result of a change in the combinations of molecules or in a change in the atom itself. In this light, chemical energy is divided into two categories--bond and nuclear energy. Under suitable conditions, atoms may combine to form molecules. Energy is required to hold the atoms together to form a molecule and is known as bond energy. If the bond between the atoms in a molecule is broken, the energy that originally held the atoms together is released. For example, if a piece of wood $(C_6H_{10}O_5)_x$ is burned, heat is given off. This heat is formed as the result of the bonds between the carbon atoms being broken. Another example of the release of bond energy occurs in the living cell when a molecule of glucose $(C_6H_{12}O_6)$ is respired.

However, burning (combustion) releases energy rapidly with considerable production of heat. Respiration releases energy more slowly with little heat given off and the majority of released energy is stored again as bond energy in a molecule of A. T. P. (adenosine triphosphate). When the cell needs energy, the A. T. P. molecule breaks down into A. D. P. (adenosine diphosphate) plus phosphate plus energy.

$$\text{A.T.P.} \longleftrightarrow \text{A.D.P.} + \text{P} + \text{Energy}$$

This is a reversible reaction. The A.D.P. plus phosphate traps the energy as it is released by respiration and stores it as A.T.P. until it is needed. The energy stored by A.T.P. is the same energy absorbed by the green plant from the sun during photosynthesis.

Nuclear (atomic) energy is energy released by an atom by either fusion or fission. When the nuclei of two or more lighter elements combine to form the nucleus of a heavier element, energy is released by mass being converted to energy. This process occurs in the stars and the hydrogen bomb and is called fusion. The most common example is the fusing of hydrogen nuclei to form a helium nucleus. Atomic energy by fission is produced when the nucleus of a heavy element, such as U_{238}, is split by neutrons to form the nuclei of lighter elements, such as Barium and Krypton. The splitting of the atom is achieved by bombarding the unstable nucleus with a neutron. This causes the nucleus to decay. A tremendous amount of energy is released in relation to the mass involved.

Energy can be found in many forms (examples are listed in the outline). The important thing to remember is that one form of energy can change into any other form of energy.

All forms of energy can be traced back to the sun. Consequently, the sun is our true source of energy, and all living things depend on this energy. The green plants are the major transformers of radiant energy into usable forms for other organisms by the process called photosynthesis (for more details on photosynthesis, see the unit on plants).

Fossil fuels, in a sense, are storehouses of radiant energy that reached the earth millions of years ago. These fuels provide the major source of energy for most nations. Coal, formed from vegetation by a process of heat and pressure, is divided into several categories--peat, lignite, soft (bituminous), and hard (anthracite). Petroleum is formed from plant and animal remains and is trapped in the earth's crust in permeable rock (sandstone) layers between impervious rock layers (shale).

Water, because of its gravitational energy, is a prime source of energy. Water energy can be useful or harmful. It may be useful when it is used to generate electricity. It may be harmful when it causes erosion. Water erodes soil by rill, sheet, gully, and riparian erosion (more information in the units on soil and water).

Windmills and sailboats put wind to work as a source of energy for man. However, wind is not a major source of energy for useful work.

Energy is usually measured by the amount of work it does or can do. Work is usually measured in foot pounds. That is, the weight of the object moved (in pounds) times the vertical distance (in feet) it is moved. A thermometer is used to measure the amount of heat energy (average kinetic energy of all the molecules) in an object. It can be measured in the Centigrade scale (water freezes at 0^{o} and boils at 100^{o}), Fahrenheit scale (water freezes at 32^{o} and boils at 212^{o}), and absolute or Kelvin scale where absolute zero is equal to -273.1^{o}C.

Heat is measured in calories (metric) or British Thermal Unit (B. T. U.) (English) units. A calorie is the amount of heat required to raise the temperature of one gram of water 1° C. A B. T. U. is the amount of heat required to raise the temperature of one pound of water 1° F.

Electrical energy is measured in watts and watt-hours. A watt is equal to 1/746 of a horsepower (1 H. P. = 33,000 ft. lb./min.). A watt-hour is a unit of work equivalent to the power of 1 watt for 1 hour or 2,655 ft. lb. The prefix kilo is added to the above terms to indicate 1,000 times.

Energy consumption can be used as a measure of a nation's standard of living. In general, the more energy consumed, the more leisure time, and the better the people of a nation live.

The Law of Conservation of Energy and the Law of Conservation of Mass state that neither mass nor energy can be created or destroyed, only transformed. Einstein combined these two ideas into a mathematical equation ($E = MC^2$) that makes the two laws more plausible. That is, the sum total of mass and energy remains constant in any transformation; but mass may be converted into energy, and energy may be converted into mass.

Any form of energy may be transformed into any other form of energy, such as electrical to mechanical. However, it has been shown that when a body gains energy, its mass increases--the extra mass is because of the gained energy. When matter emits radiation, it loses a small bit of mass. Therefore, we can say that particles of matter are interchangeable with radiation; and thereby, are able to be interchangeable with other forms of energy.

Each time energy is transformed, there is a loss of available energy to do work. This can be illustrated with the electric motor. A certain amount of electrical energy enters the motor to be converted to mechanical energy. The amount of mechanical energy available to do work will be less than the amount of energy entering the motor because some of the original energy will be used to overcome inertia and friction within the motor.

In general, energy may be transferred in three ways: radiation, conduction, and convection. Conduction is the transfer of energy from one molecule to the next and occurs primarily in solids. As one molecule receives energy, it becomes more excited and increases its movement until it touches the molecule next to it and transfers energy to it. This continues until all of the molecules are excited, or the energy source is removed. Convection occurs primarily in fluids (liquids and gases) and results in the spaces between the molecules becoming larger. This makes it less dense than the surrounding molecules which, in turn, are attracted more strongly by gravity and are pulled downward. This forces the heated molecule upward, and the process is repeated with other molecules forming a stream of molecules referred to as a convection current. Eventually, the original expanded fluid loses some energy and starts to contract making it more dense; thus, gravitational attraction is increased, and the fluid is again attracted toward the energy source. Radiation transfers energy without the use of any molecules. A good example of this is the way the energy from the sun reaches the earth.

Early man (1.75 million years B.P. to 700,000 years B.P.) (B.P. = before present) lived in small groups and preyed on very small animals as his energy source. These animals were acquired by hunting and fishing. At this point, man was simply a user of energy. As the central nervous system developed and became integrated, the learning capacity of man increased, and he started to use fire. Fire, the first form of energy controlled by man, was used to cook his food and warm his shelters.

Man still did not control his food (energy) supply. Cro-magnon man started some control over the energy supply with the advent of the part-time hunter and part-time priest. These men provided a service to the rest of the people which released them from the task of self-support. The emergence of full-time specialists in a civilization does not take place until man develops a more complete control of his food supply. Having used a hunting style designed to produce great quantities of meat whenever possible, men had more control over their food supply, but only during certain seasons. They traveled the same migratory paths used by large herds of bison and antelope.

About 10,000 years ago, these men discovered the advantage of keeping more docile members of certain animal herds in a corral. When winter approached, weak, diseased, and overly aggressive animals were slaughtered for food. This was the start of selective breeding. In this manner, man has contrived to control his food supply and has started domestication of animals.

Domestication of animals led to the emergence of sedentary villages, pottery making, and other new cultural features. Plant domestication and the production of food on a large scale released many of the population from the task of food procurement and ushered in at 3,300 B.C. (the birth of civilization in the Near East) the urban revolution with its classes of priests, potters, soldiers, and builders. Man now controlled his food cycle at most of its points.

Energy utilization was one of the bases for the type of cultural behavior archaeologists call urbanization. The energy exchange which exists between the cultural, biological, and physical environments varies from culture area to cultural area; and as each environment offers different problems of energy utilization, the response by man will vary and different cultures will emerge.

The four major centers of culture (Mesoamerica, China, the Near East, and the Indus Valley of India) faced various energy utilization problems; and, thus, formation of contrasting cultures. Different energy utilization problems existed because of diversity in climates and terrain; and, therefore, a variance of wild animals and plants were present for domestication.

Once domestication of plants and animals occurred, energy utilization problems became very similar. By 1500 B.C., civilization flourished in each of these areas. Each had an agricultural base, but no two had the same staple crop or method of production.

In Egypt and the Mesopotamian Valley, the value crops were wheat and barley. Wheat was gradually replaced by rye. Cattle and pigs were maintained in large corrals and represented the major source of protein and beasts of burden.

The early Mayan and Toltec peoples of Mesoamerica (Central America) farmed on rivers and lakes by building massive platforms (chinampas) which floated from shore. They raised maize, peppers, tomatoes, and potatoes on these rafts. Dogs were also raised for food. These people hunted and ate jaguar, ocelots, and pumas and had no beasts of burden. Consequently, this civilization utilized the energy of slaves to a far greater extent than did Egypt.

In China, rice was the prinicple crop. Dogs and pigs were the only domesticated animals until the Mongol herders introduced the onager (wild ass).

Early peoples in India subsisted on wheat and a form of wild corn. Pigs, goats, and sheep were used as food animals; but the pattern was either just pigs where wheat was raised or goats and sheep where corn was raised due to the climate and terrain.

Man's civilization and culture depend very much on his utilization and control of energy. If the food supply is obtained by hunting and fishing, there is little control over the energy supply; and practically all of man's energy is used to obtain the next day's supply of energy. Domestication of animals and plants allowed man some time and energy to devote to purposes other than acquiring food. Therefore, the greater control man has of his food supply, the more time and energy he can devote to other activities.

OUTLINE OF CONTENT MATERIAL

- I. Description
  - A. Definition: ability to do work.
    - 1. Work (force times distance).
    - 2. Power (rate of doing work).
  - B. Categories.
    - 1. Potential (stored energy).
      - a. Due to gravitation or position.
      - b. Due to chemical or other qualities within the material.
    - 2. Kinetic (energy of moving objects).
  - C. Ability to be interchanged.
    - Example: Swinging pendulum.

- II. Types of Energy
  - A. Gravitational - Position causes an object to have potential energy.
    - Example: A rock at the top of a cliff.
  - B. Mechanical - Momentum gives an object the ability to do work.
    - Example: Moving water, rotating wheel, and projectile in flight.
  - C. Electrical - An electron is a negative charge of electricity.
    - Example: A stream of electrons flowing through a wire (a conductor) is an electrical current--one of the most useful forms of energy.
  - D. Chemical.
    - 1. Bond energy - The energy required to cause atoms to combine into a molecule is locked into the molecule. If the bond is broken, energy is released.
      - Example: Burning a piece of wood (mostly cellulose) produces heat by breaking the carbon bonds. This is the same energy originally absorbed by the plant from the sun. A living cell breaks down glucose ($C_6H_{12}O_6$) by respiration and energy is liberated.
    - a. Combustion (burning) - Energy is released rapidly and much heat is given off.
    - b. Respiration (cellular energy release in a living organism) - Energy is released slowly with little heat given off. Most of the energy released is stored again as bond energy in a molecule of A.T.P. (adenosine triphosphate).
      - 1. A.T.P. acts as a storage reservoir for energy.
      - 2. Energy is released as the cell needs it by breaking A.T.P. into A.D.P. (adenosine diphosphate) and phosphate.

A.T.P. ⟷ A.D.P. + P + Energy
(reversible reaction)

2. Nuclear (atomic energy) - Energy is released due to a change in the nucleus of an atom.
    a. Fission.
        1. One pound Uranium = 2 1/2 million times the energy produced by one pound of coal.
        2. The splitting of a heavy nucleus to form the nuclei of lighter elements.
            Example: Uranium to Barium and Krypton.
    b. Fusion.
        1. One pound of Hydrogen to Helium produces 20 million times the energy produced by one pound of coal.
        2. The nuclei of lighter elements combine to form the nucleus of a heavier element.
            Example: Hydrogen to Helium.
    c. Radioactive material - Energy is released by the decaying of the nucleus (radiation).
        1. Alpha particles (nucleus of a helium atom).
        2. Beta particle (an electron).
        3. Gamma rays (form of radiant energy).
    d. Amount of energy released is tremendous in relation to the mass of the material involved.
    e. Radiant energy.
        1. Sun.
            Examples: Heat and light.
        2. Radio and television waves.
        3. X-ray.

III. Forms of Energy
    A. Heat.
    B. Light.
    C. Chemical.
    D. Electrical.
    E. Mechanical.
    F. Sound.
    G. Nuclear.
    H. Radiant.

IV. Sources of Energy
    A. The sun.
        1. Provides the ultimate source of energy for all plants and animals.
        2. Helps to determine the type of vegetation and animal life.
        3. Helps to determine the way people make a living.
        4. Helps to determine the total culture of a people.

B. Plants.
   1. Photosynthesis stores energy in the plant.
   2. Provides food for animals.

C. Fossil fuels--major sources of energy for all nations.
   1. Coal.
      a. Geological formation of coal.
      b. Mining of coal.
      c. Effect on the economy of an area.
      d. Types of coal: bituminous and anthracite.
   2. Petroleum.
      a. Formation of petroleum.
      b. Drilling for oil.
      c. Effect on economy of an area.
      d. Refining petroleum.
   3. Natural gas.
      a. Formation of natural gas.
      b. Drilling for natural gas.
      c. Effect on economy of an area.

D. Water.
   1. Constructive uses.
      a. Provides power for industry.
         Example: Hydroelectric plants in Niagara Falls, T.V.A., Hoover Dam, and Grand Coulee Dam.
      b. An important means of transportation.
      c. A major source of recreation.
   2. Destructive uses.
      a. Erosion of topsoil.
      b. Flooding.
      c. Pollution.

E. Wind.
   1. Constructive uses: windmill, sailboats, etc.
   2. Destructive forms.
      a. Hurricanes and tornadoes.
      b. Erosion.
         1. Dust storms.
         2. Abrasion of materials.

F. Miscellaneous.
   1. The atom - nuclear reactors.
      a. Peace-time uses: electricity, etc.
      b. War-time uses and responsibilities involved.
      c. Radiation fallout.
   2. Earth - internal heat (heat pump).
   3. Explosives: Gunpowder, nitroglycerin, dynamite, and T.N.T.

G. Sources of energy in percentages of the total (United States).*

Year	Coal	Oil	Natural Gas	Hydroelectricity	Wood
1850	9.3	----	----	---	20.7
1900	71.4	2.4	2.6	2.6	21.0
1930	57.5	23.8	9.1	3.3	6.1
1955	28.7	40.0	25.0	3.7	2.6

*From Shurr & Netschart, Energy in the American Economy, Johns Hopkins Press.

H. Evaluation of the sources of energy.
  1. Concentration.
  2. Convertibility.
  3. Convenience.

V. Measurement of Energy
  A. Energy of "work" - foot pound.
  B. Heat energy.
    1. Thermometers.
      a. Centigrade scale.
      b. Fahrenheit scale.
      c. Absolute scale.
    2. Heat units.
      a. Metric system - calorie and kilocalorie.
      b. English system - British Thermal Unit (B.T.U.).
  C. Electrical energy.
    1. Watt and kilowatt.
    2. Watt-hour and kilowatt-hour.
  D. Energy as a measurement of a nation's standard of living.
    1. Energy consumed is directly proportional to a nation's standard of living.
      a. Earliest man consumed 2,000 to 3,000 calories/day (as food only).
      b. Discovery of fire and domestication of animals increased man's calorie intake to 10,000 calories/day (as food plus other forms).
      c. By 1965, calorie intake totaled 192,000 calories/day as man made use of falling water, coal, oil, and gas energy.
    2. Energy consumed is directly proportional to the amount of leisure time enjoyed by a nation.
      a. Estimated that in the United States today, our use of energy (appliances, etc.) has given each of us the work output of 200 slaves.
      b. By the end of this century, we should have the equivalent of 300 slaves.
    3. Energy consumption in the United States.
      a. 1900: The United States with 6% of the world population consumed 1/3 of the world's total energy production.

b. Heat and power for:
  1. Industry - 35.5%
  2. Residential use - 20.0% } = 64%.
  3. Commercial use - 8.5%
  4. Transportation - 20.3% (10% for private automobiles).
  5. Other activities - 16% (industry, agriculture, government, and military).

VI. Conservation of Mass and Energy
  A. Accepted theories.
    1. Helmholtz (1847) stated that energy cannot be created or destroyed but may be transformed from one form to another.
      Example: Electrical to mechanical.
    2. Lomonsov (1756) and Lavoisier (1783) independently stated that matter cannot be created or destroyed but may be transformed from one form to another.
      Example: Ice to water to steam.
    3. The two generalizations combined.
      a. Not exactly accurate as stated above.
      b. Einstein combined them into a mathematical equation: $E = MC^2$, where: E = energy in ergs, M = mass in grams, and C = a constant (velocity of light) (3×10^{10} cm./sec.).
  B. Conserving energy as a natural resource.
    1. Increase the efficiency of methods used to obtain energy.
    2. Increase the efficiency of distribution of the energy sources.
    3. Increase the efficiency in the utilization of the energy sources.
  C. There is a constant amount of energy and mass in the universe and the total alters only in form.
  D. What has been the government's function in the conservation of energy or potential energy?
    1. Must regulate for the sake of long-term social interest the desire for quick profits in the extracting industries.
    2. Must eliminate the wasting of nonrenewable energy sources.
    3. Must develop and utilize resources of all types for the maximum satisfaction of social needs.

VII. Transformation of Energy
  A. Types.
    1. Electrical to mechanical.
    2. Electrical to light.
    3. Electrical to sound.
    4. Mechanical to electrical.
    5. Chemical to heat.

    6. Chemical to mechanical.
    7. Chemical to electrical.
    8. Sound to electrical.
  B. Constancy.
     Example: Sunlight (radiant) may be absorbed by a green plant, converted to bond energy in a glucose molecule. This may then be transformed into wood. The plant dies and the wood may be transformed into coal over a period of time (millions of years). The coal may then be burned producing heat and light. The heat may be used to convert water into steam to turn a turbine to operate a dynamo to generate electricity. The electricity may be used to produce mechanical energy, light, or many other uses.
  C. Mass to energy – energy to mass.
    1. When a body gains energy, its mass increases.
    2. When matter emits radiation, it loses a small bit of mass.
    3. Any form of energy can be converted into any other form.
  D. Loss of energy.
    1. Each change that occurs reduces the amount of energy available for work when compared to the original amount of energy.
    2. The causes are inertia, gravity, friction, and molecular forces (cohesion and adhesion).

VIII. Transferring of Energy
  A. Heat energy.
    1. By conduction.
    2. By convection.
    3. By radiation.
  B. Electrical energy.
    1. Conductors.
    2. Insulators.

IX. History of Man and Energy
  A. 1.75 million years B.P. to approximately 700,000 B.P., man-like forms lived in small groups of nomadic hunters.
  B. 700,000 to 600,000 years ago, man learned to use fire.
    1. Cooking, heating the cave, etc.
    2. Man's first step in control of energy, but in only one form.
  C. Cro-magnon man – first to start control of food supply (energy supply).
  D. About 10,000 years ago, domestication of more docile animals began.
    1. More control over food supply.
    2. Indirect selective breeding.
    3. Sheep and goats were domesticated first.

   4. Pigs were domesticated next.
   5. Cow was domesticated about 5,000 years ago.

E. Domestication of animals prompted formation of sedentary villages.
   1. Pottery making and other new cultural features.
   2. Domestication of plants.
      a. Urban revolution.
      b. Man now controlled the energy cycle at most of its points.

F. Formation of civilizations and culture.
   1. Based on energy utilization.
   2. Different environments present different problems of energy utilization by man.
   3. Four major cultural areas of the world.
      a. Mesoamerica.
      b. China.
      c. The Near East.
      d. The Indus Valley of India.
   4. All had an agricultural base but different staple crops.
      a. Mesoamerica (Mayan and Toltec peoples).
         1. Maize, peppers, potatoes, and tomatoes.
         2. Raised food on chinampas.
         3. Raised dogs for food - hunted and ate jaguar, ocelots, and pumas.
         4. Did not have beasts of burden.
      b. China.
         1. Rice.
         2. Dogs, pigs, and onagers only animals.
      c. The Near East.
         1. Wheat and barley followed by rye.
         2. Cattle and pigs.
            a. Food supply.
            b. Beasts of burden.
      d. India.
         1. Wheat and a form of wild corn.
         2. Pigs, goats, and sheep.

G. Modern day energy consumption.
   1. Industrialized countries use the most.
      a. United States.
      b. Russia.
   2. Non-industrialized areas.
      a. Africa.
      b. Asia.
      c. Middle East.
      d. Latin America.
      e. These countries will make increasing demands on the energy supply.

3. Fossil fuel reserve.
    a. Knowledge based on known technology and supplies.
    b. Assumptions.
        1. Whole world would become industrialized.
        2. Coal would last 150 years.
        3. Oil and natural gas would last less than 150 years.
        4. These are irreplacable.
4. Atomic energy.
    a. Number - approximately 200 reactors in the United States.
    b. Problems involved.
        1. Acquiring the proper fuel.
        2. Large capital outlay for the reactor.
        3. Disposing of radioactive waste material.
        4. Thermal pollution.
        5. Must be a large-scale operation to be economical.
5. Major effects of increased energy availability.
    a. Allows us to do many things with less effort and in less time and increases leisure time.
    b. Allows us to do things that were not possible before.
        1. Refrigeration.
        2. Flight.
        3. Space travel.
6. Need for management of energy.
    a. Mastery of energy may lead to man's destruction.
       Example: Wage war on a more efficient and greater scale.
    b. Mastery of energy may lead to a better life.
        1. Less effort involved in work.
        2. More leisure time.
    c. The role of government in establishing goals in a democratic society.
    d. Implementation of the goals established by the government.
    e. The role of private business.
    f. The role of and the responsibility of the private citizen.

LEARNING ACTIVITIES AND MATERIALS

I. Learning Activities

A. Demonstrations.

1. Place a radiometer in the sunlight and explain how the device detects the presence of radiant energy. Discuss how the radiometer converts radiant energy into kinetic energy of motion.
2. Use a Geiger Counter to detect radiation at different locations. Discuss radiation fallout as a hazard.
3. Make a thermometer by placing a one-hole stopper containing a long piece of glass tubing into a Florence flask. Fill the system with colored water. Determine the "fixed points" (freezing and boiling points) by first placing it in a mixture of ice and water and then in a steam bath.
4. Measure the temperature of mercury in a container. Stopper it tightly and insulate the container to avoid heat transfer from any external source. Shake the container vigorously for a few minutes and again measure the temperature of the mercury. This will readily illustrate the heat equivalent of mechanical energy.
5. Drop melted wax at regular intervals along the length of a metal rod. Place a thumb tack in the wax droplets before the wax hardens. Hold the rod with a pliers and heat the other end in an open flame. The sequence in which the tacks drop off indicate the conduction of heat. Repeat, using a wooden rod. Explain the different results.
6. Begin heating a full beaker of water on one side of the beaker bottom. Add several pinches of fine sawdust to the water. Detect the convection current.
7. Fill two beakers with water and add ink to one. Check the temperature of each beaker and place them in a sunny location for one hour. Stir the water and record any difference in temperature.
8. Destructively distill a given weight of bituminous coal in a hard pyrex test tube. Emphasize that although the forms of matter have changed, the total available energy from the system remains the same.
9. By means of a screw eye, attach a two-foot string to a one-inch wooden ball. Attach the string to a solid support and using the ball as a pendulum, permit it to swing back and forth. How long does it take to stop swinging? Attach another string of the same length to another ball of the same size and weight. Hang this second ball adjacent to the first one in such a manner that the two balls just touch. Carefully pull ball No. 1 away from ball No. 2 and permit it to swing down and hit ball No 2. What happens? Explain. How long before the two balls come to rest?
10. Place a tablespoonful of sugar (sucrose) on the bottom of a 250 c.c. pyrex beaker and place in the center of a piece of plate glass 18" x 18". Carefully add 10 c.c. of concentrated sulfuric acid (H_2SO_4). This is an example of the release of bond energy (chemical energy).

11. Secure a flashlight lens (double convex) and use it to focus the rays of the sun on a single point of paper.
12. Drive a car from a cool garage or shaded area into direct sunlight. Place a thermometer in the car and close all the windows. An hour later, note the temperature and compare with the original temperature.
13. Secure two 500 c.c. pyrex beakers. Fill one with hot water (150° F.) and the other with ice water. Drop a cube of sugar into each beaker. Which cube of sugar dissolves first? Why?
14. Secure two similar thermometers and wrap the bulb of each in a handkerchief. Record the temperature registered by each thermometer. Soak one handkerchief in water at room temperature; the other remains dry. Fan both thermometers for several minutes. Compare the two temperatures.
15. Make a paper pin wheel and hold it in front of an electric fan. Turn on the fan. What happens? Place the pin wheel above a candle. What happens?
16. Punch a hole in the center of three pieces of cardboard. Place the cards ten inches apart and hold the flashlight in front of them. Move one of the cards slightly out of line and repeat. This illustrates the straight line movement of light.
17. Hold a glass close to a light source and note how the light passes through the glass. Hold a piece of paraffin close to the light source and note the absorption of radiant energy and conversion to heat. Hold a mirror to the light source and note the reflection. Three actions: pass through, absorb, or reflect.
18. Fill five glass jars of equal size with water. Cover each jar with a different color: red, green, black, yellow, and white. Place a one-hole stopper with a thermometer in each jar and place in direct sunlight for approximately one hour. Record the temperature in the beginning and at the end of the experiment. Note and explain any differences. How does this affect you?
19. Place two thermometers on the ground in direct sunlight about two feet apart. Cover one thermometer with smooth, black material and the other with rough, black material. Record the temperatures after one hour. Explain any differences.
20. Cover a jar filled with water with black cloth and shine a high intensity light directly on the jar for one hour. Record the temperature before and after the experiment.
21. Place one potted plant in complete darkness and another potted plant in sunlight. Water and temperature should be kept constant for both plants. Observe both plants every few days and record the differences. Explain.
22. Using a light meter, record the light intensity in an open area in a forest and note the number of plants growing in a three-foot square. Repeat the

same procedure in a shaded area. Compare the number of plants and the different species in each area. Explain the difference.

23. Dilute sulfuric acid by pouring concentrated acid into water and note the liberation of heat.
24. Drop a crystal of sodium thiosulfate into a saturated solution of sodium thiosulfate in a test tube. Heat will be liberated as crystals form. This is known as heat of crystallization.
25. Examine and explain the dry cell and the wet cell.
26. Explain and demonstrate working models of the automobile, diesel, and aircraft engine.

B. Field trips.
   1. A trip to a shaft coal mine and/or strip mine.
   2. A trip to an electric generating plant.
   3. A trip to an old-fashioned grist mill operated by water power.
   4. Visit the furnace room of your school.
   5. A trip to an oil field and gasoline refinery.
   6. A trip to see a cyclotron at the University of Pittsburgh or a nuclear reactor at the Pennsylvania State University or Saxton, Pennsylvania.
   7. A trip to see a steam engine in action.

C. Discussion.
   1. Debate:
      a. Resolved: The federal government should abolish the electrical power projects.
   2. Discuss the various types of food needed for good health.
   3. Compare the energy content of different foods (fats to proteins).
   4. How long will our present supply of fuel last (coal, oil, etc.)?
   5. What are the advantages and disadvantages of nuclear power?
   6. How is our electricity generated?
   7. Discuss the ways in which we use energy.
   8. Discuss work as scientists define the term compared to the way most people refer to it.
   9. Discuss potential and kinetic energy. Discuss why some objects have potential energy in some situations but not in others.
   10. List the factors that determine one's daily calorie intake. Compare the laborer to an office employee.
   11. Discuss the three criteria of judging a fuel: convenience, convertibility, and concentration.
   12. Every form of energy can be regarded as kinetic energy or potential energy or some combination of them. Why is this so?
   13. Consider the changing energy forms involved in turning on a flashlight.
   14. The future course of civilization will be strongly influenced by the way in which we use freedom from routine and repetitious operations which energy is giving to us in the form of more leisure time. What will it be used for?

    15. Explain the early uses of water power and how engineering has helped to improve its uses.
    16. Why is the use of water power so limited at the present time?
  D. Bulletin board displays to show:
    1. Where our energy comes from.
    2. How we use coal, petroleum, and nuclear energy.
    3. Where our food comes from.
    4. Benefits which we receive from the sun.
  E. Student activities and projects.
    1. Make a waterwheel, windmill, or electric motor.
    2. Make maps to show state parks and other recreation parks in the state.
    3. Write reports on conservationists--Gifford Pinchot, Theodore Roosevelt, etc.
    4. Write a paper.
      a. The pros and cons of government intervention in the conservation of resources of energy.
      b. Who owns America?
      c. Energy and potential energy sources.
      d. Trace the energy found in food and fuels back to the energy of the sun.
      e. Submit a paper on what you believe to be the role of sources of energy and their conservation for the nation's future.
    5. Make models of the three classes of levers.
    6. Set up a system of pulleys to show mechanical advantage.
    7. Secure a thin, copper wire (insulation removed) and place it between the terminals of a dry cell. Touch the wire with your finger to note any temperature change.
    8. Secure a rubber balloon and inflate it until it reaches a safe size. Fasten the balloon to a soda straw, pass a wire through the straw, and release the balloon. This should help explain how a jet motor works.
    9. Secure four blocks of wood 2" x 4" x 4". Two of these are to be used in Part A and the other two in Part B. (A) Hold one of the blocks of wood against the cheek to note the temperature. Now rub the two blocks of wood together vigorously for several minutes and again place against the cheek to note temperature. (B) Repeat A, but this time apply a liberal amount of vaseline to each of the two surfaces to be rubbed together.

II. Learning Materials
  A. Audio-visual materials.
    1. See list of sources at the end of the guide.
  B. Books and pamphlets.
    1. Earth Science Curriculum Project, Investigating the Earth, revised 1965 text (unpublished).

2. Braidwood, R., Prehistoric Man, University of Chicago Press, 1957.
3. Braidwood, R. and Howe, B., Studies in Ancient Oriental Civilization, No. 31, University of Chicago Press, 1960.
4. Brenil, H. and Lantier, R., The Man of the Old Stone Age, St. Martin's Press, New York, 1959.
5. Brown, H., The Challenge of Man's Future, The Viking Press, 290 pp., 1953.
6. Cambel, A. B., "Energy", Science Journal, V. 3, No. 10, pp. 57-62, October, 1967.
7. Chalmers, B., Energy, Academic Press, New York, 289 pp., 1963.
8. Emmerich, W., Gottleib, M., Helstrom, C., and Stewart, W., Energy Does Matter, a Westinghouse Search Book, Walker and Company, New York, 250 pp., 1964.
9. Hawkes, J., The World of the Past, Vols. 1 and 2, A. Knopf Company, New York, 1963.
10. Hefferman, Helen and Shaftel, George, The Energy Story, L. W. Singer Company, Syracuse, New York, 1963.
11. Heizer, R., The Archaeologist at Work, Harper and Row, 1959.
12. Kennedy, F. L., "Energy Comes of Age", a print of an address at Juniata College, Huntingdon, Pennsylvania, November 20, 1964.
13. Landsberg, H. H., Fischman, L. L., and Fisher, J. L., Resources in America's Future, Patterns of Requirements and Availabilities 1960-2000, Johns Hopkins Press, 1017 pp., 1963.
14. Life Science Library, Time Incorporated, New York, New York.
    - Matter.
    - Energy.
    - Wheels.
    - Machines.
15. Nevins, A., Dunlop, R. B., Teller, R., Mason, E. S., and Hoover, Herbert Jr., Energy and Man, a symposium, Appleton-Century-Crofts, Inc., New York, 113 pp., 1960.
16. Rogers, E. M., Physics for the Inquiring Mind, 778 pp., Princeton University Press, 1960.
17. Valley Preliminary Report, Pennsylvania State University Press, 1963.
18. Seaborg, Glenn T., "Horizons Stretch for Tiny Atom", The Christian Science Monitor, p. 13, Friday, November 10, 1967.
19. Seaborg, Glenn T., "The Promise of the International Atomic Energy Agency", Science, Vol. 158, No. 3798, pp. 226-230, October 13, 1967.
20. Schurr, S. H., "Energy", Scientific American, Vol. 209, No. 3, pp. 110-126, September, 1963.
21. Soustelle, J., Daily Life of the Aztecs, MacMillan Company, 1955.

MINERALS

BACKGROUND INFORMATION

The United States has been endowed with great mineral wealth. These abundant mineral resources have helped establish a broad base for the great industrial society which we have forged.

A mineral can be defined as a naturally occurring, inorganic substance with a characteristic internal structure and with a chemical composition and physical properties that are either uniform or variable within definite limits. In this text, the term mineral is broadened to include organic, liquid, and synthetic products which have been classified as minerals in the nation's courts. Single elements may be minerals, but most minerals are inorganic compounds in a solid state.

Minerals are usually formed by precipitation from various kinds of solutions. Examples include: (1) formation of minerals from hot, liquid rock solutions that crystallized as they cooled, (2) formation of minerals from volcanic vapors that came in contact with cooler rocks, and (3) formation of minerals by chemical reactions between elements in the atmosphere or in the ground and the minerals of the rocks with which they came in contact.

The mineral composition of the earth is not homogeneous. Minerals may be concentrated by igneous activity whereby the metals crystallize early in the cooling history of a silicate magma and settle out of the melt, or they may form later and be trapped in the crystallized melt. It is more common for metallic elements to become mixed with hot, igneous volatiles, mostly water, and be injected into surrounding rocks forming hydrothermal deposits.

The weathering process concentrates minerals by alteration of compounds from which elements could not otherwise be economically extracted. This includes removal of undesired components from rocks and leaving the desired components more concentrated than they were originally. The solution of materials at the surface and redeposition of desired elements at depth in useful concentrations also concentrates minerals.

The sedimentary processes produce concentration by chemical precipitation in sediments by evaporation of sea water and by the chemical and physical processes involved in weathering and erosion. This would also include the placer process, as in the deposition of gold.

The surface of the earth comprises approximately sixty million square miles of land above sea level. Some of this surface is solid rock, but much of it is small fragments. The loose material on the surface is called mantle rock, and the solid rock beneath is called bedrock.

The rigid outer shell of the earth is called the crust which is very thin in comparison with the other two layers. The thickness of the crust varies from thirty miles thick on land to five miles thick under the ocean.

The mantle is about eighteen hundred miles thick and is composed of solid magnesium and iron silicates with some pockets of molten material. The temperature gradient of the rock in this layer is approximately 300° C. to 500° C. under the crust to 3,000° C. at the mantle-core boundary.

The center of the earth, the core, makes up the largest part of the earth and is about forty-two hundred miles in diameter.

The minerals with which we are concerned are found in the crust of the earth. Scientists recognize ninety-two different elements that occur normally in the crust. Some of these elements (oxygen and silica) are very abundant and widespread; others (iron and potassium) are universally present, but only locally abundant; still others (silver and gold) are quite rare and seldom present in commercially valuable concentrations. The following table shows the percentage compositions of elements in the earth's crust:

Element	Percentage of Earth's Crust by Weight
Oxygen	46.60
Silicon	27.72
Aluminum	8.13
Iron	5.00
Calcium	3.63
Sodium	2.83
Potassium	2.59
Titanium	.44
Hydrogen	.14
Phosphorus	.12
Manganese	.10
Sulfur	.05
Carbon	.03
Chlorine	.03
All Others	2.59*

Rarely are these elements found free (uncombined) in nature. Instead they usually combine with one another in definite proportions to form compounds.

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*Pearl, Richard M., Geology - College Outline Series, p. 64, Barnes & Noble Publishing Company, New York.

Work provided in handling minerals creates millions of jobs around the world. In the United States alone, there are five million workers in the mining and mineral manufacturing industries. Mineral production in the United States has a value of about twenty billion dollars annually. The total estimated value of the world's mineral production in 1960 was approximately fifty billion dollars. Fuels represented thirty-seven billion of the total. Each year there are growing demands made upon our deposits. It seems that man has not been overly concerned about future supplies of minerals because he has been able to meet shortages, thus far, by prospecting, substitution of new materials, and reusing scrap metals.

Minerals, unlike other resources, are not renewable. Our mineral deposits are constantly being consumed, but more and more efficient methods of utilizing minerals are being discovered. As our high quality minerals and ores are used, methods must be discovered to obtain metals from the poorer grade ores. The United States imports over seventy-five per cent of its mineral needs of twenty different mineral commodities. In fact, the United States consumes twenty-five per cent of the world's total production of metals.

The composition of minerals ranges from single elements to complex compounds containing ten or more elements. Approximately two thousand different minerals are recognized today. The silicates are by far the most abundant minerals in the earth's crust.

Minerals occur in many chemical forms. The following classes indicate some of the most common forms using chemical properties as a basis for classification.

Halides are minerals which are simple compounds of chlorine, fluorine, bromine, or iodine combined with a metal. The halogens have seven electrons in their outer shells and readily gain an electron when reacting with metals to form the stable halide ions. Examples of halides include fluorite containing calcium fluoride and cryolite which contains sodium, aluminum, and fluorine.

Silicates consist of the elements silicon and oxygen combined with one or more of the metallic elements. The element silicon has four electrons in its outer ring; but since it reacts often with many elements in a given mineral, the electron distribution becomes very complex. Silicon is to the inorganic world what carbon is to the organic world. It is more active chemically and is heavier; and since it is directly under carbon in the periodic table, it has many similar properties. It has a marked tendency to form chains of alternating silicon and oxygen atoms much as carbon forms chains of carbon atoms. Together with oxygen, silicon makes up seventy-five per cent of the total weight of the crust of the earth. The silicate minerals formed by combination with aluminum, iron, magnesium, sodium, potassium, and/or calcium make up a major portion of the crust. In fact, more than forty per cent of the known minerals are silicates, and silica and silicates together make up seventy-eight per cent of the total weight of the earth's crust. Feldspars, micas, pyroxenes, and amphiboles are examples of minerals containing silicon.

Oxides are compounds of oxygen with any other single element. Oxygen has six electrons in its outer ring and, therefore, is an active non-metal constantly reaching for additional electrons. Oxides are very commonly found in nature. Common oxides include uraninite and the iron ores, hematite, magnetite, and limonite. The gems, the red ruby and blue sapphire, are minerals also classified as oxides. Within this class are the chief ores of iron, chromium, manganese, tin, and aluminum.

Sulfides are those minerals that contain metals combined with sulfur only. Sulfur has six electrons in its outer shell and requires two additional electrons to form a completed octet of electrons and become a sulfide ion. Galena, or lead sulfide, is the most common ore of lead. Other examples include pyrite (a pollutant from coal mining operations), sphalerite, and ores of silver, zinc, and mercury.

All carbonates contain the element carbon which contains four electrons in its outer ring. Since it is just as easy to gain four electrons as it is to lose four, carbon reacts readily as both a metal and a non-metal. All carbonates will liberate carbon dioxide when treated wtih an acid. The most common mineral containing carbonate is calcite which forms when the gas carbon dioxide reacts with calcium. Other common mineral carbonates are dolomite (calcium and magnesium carbonates), siderite (iron carbonate), and cerussite (lead carbonate).

Phosphates are minerals containing metals combined with phosphorus and oxygen. Phosphorus itself is a very active non-metal having five electrons in its outer ring. Phosphates are found in the bones of animals as calcium phosphate and in the rocks as phospherite or collophanite which are forms of the mineral apatite.

Sulfates are compounds of oxygen and sulfur combined with one or more of the metals. Gypsum is the most common sulfate among the minerals. Bariet and anhydrite also belong to this group.

The arsenates and vanadates are minerals composed of metals combined with oxygen and either arsenic or vanadium. Examples are listed in the outline.

There are numerous other less common groups of minerals, but the nine listed above include ninety-nine per cent of all of the minerals one is apt to encounter in normal field collecting.

Classification of minerals which emphasize minerals as natural resources or as an ore often separate mineral commodities into mineral fuels, metals, and non-metals.

The first group is defined as use as a fuel or as a source of energy and is referred to as mineral fuels.

From ancient times, coal was known as the "rock that burned" in and around the Mediterranean. However, Germany and England were the first countries to use coal as a source of heat for homes and industry.

Coal was discovered early in colonial America but was not used greatly because of the large and readily available supply of wood. The first coal that was mined in the United States was mined in 1787 in Virginia. After mining operations were begun in Pennsylvania, anthracite was soon being used as a source of energy.

Coal is defined as a solid, carbon-bearing, naturally occurring material. Chemically, it consists mainly of pure carbon or carbon in some sort of oxidized carbohydrate.

The formation of coal involves the decay of plants under moist, swamplike conditions. The swamp waters under which the plants were buried excluded oxygen, and as a result, the plant material partly decomposed but did not entirely rot away. Instead, it became a colloidal mass referred to as peat. Further addition of sediment created increased pressure and removal of moisture from the plant material until it gradually changed to coal. As pressure and temperature increase, the coal changes through a series of different grades until, at its highest grade, it may be reduced to pure carbon. Coal exists in various forms. Peat is the softest form but has not been important in the United States. Lignite, halfway between peat and bituminous in hardness, is found in the Dakotas, Montana, Wyoming, Colorado, and the Gulf states.

Bituminous or soft coal is found throughout Appalachia, from Pennsylvania and Ohio to Alabama. Michigan, Indiana, Illinois, Missouri, Kansas, and several western states have bituminous deposits. It is used in making coke which plays an important role in iron and steel production.

Anthracite, or hard coal, is found in northeastern Pennsylvania, Colorado, and New Mexico. Only the deposits in Pennsylvania have been mined to date. Hard coal is the best grade because it burns clean with very little smoke. However, anthracite is the most expensive to mine, and the supply is very limited.

Bituminous has always been our most abundant form of coal. The use of soft coal in the railroading and the steel industries increased the speed of our industrial revolution. In so doing, it helped to lay the foundations of our great society. It is interesting to note that nearness of the Pittsburgh Coal Seam helped to make that city the steel center of our country. Converted to coke in places like Connellsville, coal helped to make Pittsburgh an industrial giant. Names like the "Big Vein" coal in Maryland, "Pocahontas" coal of Virginia and West Virginia, "Moshannon Bed" near Clearfield, Pennsylvania, the "Wilmore Basin" near Johnstown, and the "Big Muddy Creek" vein in Illinois have all been important in this country's industrial development.

Depletion of coal reserves, like any other mineral resource, is of high concern. However, there are few industries where technology has been applied as vigorously as in the coal industry. Increased mechanization has helped to stabilize the cost of coal. Increased labor costs have forced the marginal mines and inefficient operations to close. This has caused a loss of employment, and economic dislocations have occurred in mining areas. However, coal is becoming a major source of electrical power east of the Mississippi. Mine-mouth power operations have added new vitality to a once sagging industry.

Western Pennsylvania has experienced a renaissance in coal mining with efficient, conservation-minded companies. Continuous mining machines and efficient engineering have replaced the old room-and-pillar concept of mining. This new retreat method of mining prevents the loss of huge pillars of coal. Experimentation with back-filling of mines to prevent the danger of subsidence seems feasible.

In 1859, Colonel Edwin Drake drilled the first oil well (69 feet deep) in the United States at Titusville, Pennsylvania. The first petroleum was used to make kerosene for lamps which were a great improvement over candles or whale-oil lamps. Pennsylvania remained the leading state in oil production until the early 1900's when the first wells were drilled in Oklahoma and Texas. Today, off-shore oil and oil from California contribute largely to United States oil production.

With the advent of the automobile, most oil was refined into gasoline, lubricants, and fuel oil. Like the coal industry, the oil industry was first typified by great waste and little thought about conservation. Wells caught fire and were allowed to burn themselves out. Gushers came in and were allowed to flow unimpeded. Currently, there is a limit to the amount of oil that can be wasted in this manner.

Oil refers to naturally occurring liquid hydrocarbons. It is thought that petroleum was formed by the decay of animal and possibly some plant remains in a reducing environment in sedimentary deposits. This seems to be proven by the fact that petroleum finds are virtually restricted to marine sedimentary rocks.

Natural gas may be the answer to some of our air pollution problems. It burns clean, leaves no ash, and can be piped anywhere. Natural gas is the gaseous hydrocarbons associated with liquid hydrocarbons.

The metal group of minerals is usually sub-divided into the precious metals (gold, silver, and platinum), non-ferrous metals (copper, lead, zinc, and tin), iron and ferrous alloy metals (iron, manganese, nickel, and tungsten), and minor metals (arsenic, beryllium, cadium, and calcium).

From Cornwall Furnace to the Mesabi Range in Minnesota, iron ore has been linked with coal in the production of steel. The first iron ore was of such high quality that it could be taken directly to the steel plants. This quality iron ore has been depleted. We have learned to use low-grade ore by utilizing the flotation process. Since 1860, the production of iron and steel became a bigger and bigger operation with fortunes made by men like Carnegie with the result that steel production is becoming concentrated under fewer and fewer corporations.

There is no material that is quite so useful and important as iron. Most iron ores come in the form of iron oxide (magnetite, hematite, and limonite being the most important). Hematite occurs in several forms, and over ninety per cent of the iron made in the United States comes from the huge deposits in Minnesota, Michigan, and Alabama.

Modern smelting operations are used today to free iron from its ores. Iron ore, coke, and a flux (largely limestone) are added as raw materials to huge blast furnaces. Hot air is blown into the furnace. Through a series of chemical changes, the iron is freed from the ore, and the waste silicates in the ore are combined into a molten slag. The slag and iron settle down in the furnace; but the slag, being less dense, floats on the iron. This is drained off first, followed by the molten iron. The iron from a blast furnace is called pig iron and contains from three to six per cent of impurities. When most of the impurities are removed from the cast iron, it is called wrought iron. Cast iron is used extensively in ornamental work. Most of the iron that is produced is converted into steel which is an alloy of iron with carbon.

Copper was the first metal used by man more than 10,000 years ago. It was found first on the island of Cyprus and was called "Cyprian metal". Prehistoric man discovered that he could make tools and weapons from copper. When small amounts of tin were mixed with molten copper, a harder metal called bronze alloy was produced. In ancient Egypt, Greece, and Rome, bronze was used to make weapons, armor, and household goods.

Chalocopyrite and chalcocite are the major copper-containing ores. Chalocite is a compound of copper (eighty per cent) and sulfur. It has metallic luster and a dark lead-gray color.

After the copper ore is mined, it is crushed and washed to separate the waste rock material called gangue. This concentrated ore is then melted in large furnaces to produce "blister copper" which is about ninety-nine per cent pure. Electrolytic refining can be used to further purify the copper.

Copper is a common metal with a red color that is malleable, ductile, and a good conductor of heat and electricity. Copper is used extensively in electrical industries in the United States. The automobile industry is the second largest user of copper. Every automobile contains about forty-five pounds of copper; most of it is in the radiator.

The effects of the discovery of various minerals have been influential in famous periods of history. The first major gold strike in the United States occurred in California in 1849. Nevada, the Black Hills, and the Alaskan Klondike have also been sites of important gold discoveries. The discovery of gold and silver did much to help settle the West, and prospectors have given a certain flavor to the history of the old West. At one time, the United States held seventy per cent of all the gold in the world. Times have changed, and we are now concerned with the outflow of gold from this country.

Silver and its "free coinage" entered into our national political scene from 1880 to 1900. "Free coinage" of silver at the ratio of sixteen to one split both major parties and forced entry of a third party onto the scene.

Aluminum is one of the chief and most abundant metals. It is steadily increasing as a substitute for other metals and will continue to grow with the economy of the United States.

Bauxite is the most important ore of aluminum. Arkansas produces most of the bauxite mined in the United States. In aluminum production, the bauxite is first crushed and washed and then converted by a series of chemical reactions into alumina or aluminum oxide. Cryolite (sodium aluminum fluoride) is mixed with alumina to produce a mixture which will conduct an electrical current. Aluminum is produced in an electrolytic cell by passing electricity through the aluminacryolite mixture. Twelve kilo-watt hours of electricity are used in making one pound of aluminum.

Aluminum is only one-third as heavy as steel and is resistant to atmospheric corrosion due to the formation of a tough continous fiber of aluminum oxide which covers its surface.

It is used extensively in making alloys, paint, electric cables, airplanes, and aluminum foil for wrapping purposes.

Lead has been used since Roman times. The early Egyptians used it for solder, and the Romans made lead pipes to carry water. Galena is the most important ore mineral containing lead. Most of our lead comes from veins in Missouri and Colorado. Much of the lead is used in paints, printing type, bullets, and leaded compounds for antiknock gasoline. It is also used in soldering and in the production of lead storage batteries. Substitutes of other materials is helping us to conserve our limited supply.

Zinc is a young metal and is always used in mixtures with other metals. The most common mineral containing zinc is sphalerite (zinc sulfide). Zinc is used in dry cells because of its chemical activities. Every flashlight battery has a zinc container which is the negative electrode. It is used as a coating on iron to produce galvanized iron and protects the iron from air oxidation.

Tin is a metal found in cassiterite, the most common tin oxide. It forms at high temperatures in igneous rocks. Tin has many uses, but the most common is probably production of tin cans. Although a tin can contains less than two per cent of tin, this is sufficient to provide a protective covering to keep oxygen in the air and acids in food from reacting with the iron in the "tin" can. The alloy of tin and copper is called bronze.

The non-metal group of minerals include: water; construction materials (stone, gypsum, cement materials); ceramic materials (clay, feldspar, bauxite, borax); metallurgical, chemical, and refractory minerals (foundry sands, limestone, dolomite); industrial and manufacturing minerals (asbestos, mica, talc, graphite); fertilizer materials (sulfur, potash, phosphate, nitrate, lime); gemstones; and synthetics (diamonds, ruby, quartz, sapphire).

Sulfur is an element which is classified as a non-metallic mineral. It has a characteristic yellow color and occurs in three allotropic forms. The largest deposits in the world are found along the Gulf coast of Louisiana and Texas. The mineral is mined by the Frasch process which consists of lowering three concentric pipes into the ground. Compressed air is forced down through the center pipe while superheated water is forced down through the outer pipe. The hot water melts the sulfur which is forced to the surface through the middle pipe by the compressed air. The most important use of sulfur is in the making of sulfuric acid.

Graphite is made of pure carbon. It is found in igneous and sedimentary rocks and is used in making "lead" for lead pencils and in making paints and lubricants.

Gypsum is a common mineral containing calcium, sulfur, and oxygen combined with water. Plaster of Paris is produced by dehydrating gypsum.

Halite is the mineral sodium chloride or ordinary table salt. It is often mined in a way similar to sulfur. Evaporation of sea water will produce halite which occurs naturally in cubic crystals which are colorless with a vitreous luster. The salty taste is perhaps its most characteristic physical property.

Borax is composed of sodium, boron, and oxygen combined with water. Most borax is derived from the related minerals of colemanite and kernite. A vast bed of colemanite was discovered in Death Valley, California, about fifty years ago. In the early days, the borax was hauled out in wagons drawn by twenty mules which gave rise to the name "twenty-mule team borax".

Fluorite is a compound of calcium and fluorine. It is the only source of the element fluorine and is an important flux in smelting ores.

Talc is an unusual non-metallic mineral known as hydrogen magnesium silicate.

Talc is used as a filler for paint, paper, and roofing. High-grade, pure talc is processed to produce talcum powder.

Asbestos is actually a combination of two or more minerals, the most common of which is serpentine. It is especially valuable because its thin, flexible fibers can be matted or woven together to produce an uncombustible non-conductor. Asbestos is used extensively for fire-proofing and insulation.

Classification of natural phenomena such as mineral deposits are attempts to order very complex natural systems for some degree of understanding. However, many of these minerals fit into two or more categories, and it becomes impossible to classify them as one or the other.

Minerals may be identified by chemical composition as mentioned before or on the basis of physical characteristics.

"Hardness", the resistance which a substance offers to being scratched by a harder body, is an important characteristic of minerals. The substance producing the scratch is harder than the one that is scratched. The harder mineral pushes aside the minute particles of the softer mineral and leaves a furrow or scratch on its surface.

The Mohs scale of hardness developed by Friederic Mohs is a series of ten minerals listed in order of hardness from the softest (talc) to the hardest (diamond). The complete scale and substitutes are shown in the outline. The numbers on the scale simply indicate relative hardness. That is, a mineral with a hardness of four is not four times as hard as one with a hardness of one.

To make the test, the unknown mineral should be scratched in turn by the minerals of the hardness scale. A harder mineral will scratch a softer mineral. Therefore, if the unknown is scratched by apatite but scratches fluorite, the hardness of the unknown is between four and five. The number of soft minerals is much greater than the number of hard ones.

Tenacity is the resistance which the minute particles of any substance offer to any effort to completely separate them from one another and is a result of the cohesion forces between the molecules.

Malleability refers to a substance that can be flattened or pounded into sheets. Metals are the only minerals which possess this characteristic, and gold is the most malleable of all.

A mineral that can be drawn out into a wire is said to be ductile. Gold and silver are more ductile than copper and aluminum, but the cost of the former prohibits their use as wire conductors in most cases.

Brittleness refers to the fact that a mineral readily breaks into smaller pieces. This condition is due to the fact that the particles are held firmly together. . Degrees of brittleness may be expressed as fragile, weak, and tough.

The characteristic of flexibility refers to a mineral that can be bent without breaking and not return to its original position. Selenite is a good example.

A mineral which will bend and spring back to its original position is called elastic, and this property is termed elasticity.

Sectile minerals can be cut with a knife without being fractured, and shavings can easily be cut from it.

Cleavage is defined as the tendency to break or split along predetermined flat planes. These planes of cleavage are always parallel to the crystal faces of the mineral. Reasons for the cleavage planes can be related to atomic structure. The atoms of which a crystal is composed may be densely crowded in certain planes. As a result, there is relatively more space between these planes, and lines of weakness result. Electrical attractions between the layers of atoms also has an influence in determining the direction of the cleavage. The types of cleavage and examples of minerals are listed in the outline.

Fracture refers to the type of breakage that occurs when a mineral breaks other than along lines of cleavage. Conchoidial fracture is a break that resembles a portion of a clamshell. When fracture approaches conchoidial, but is not distinctly developed, it is called subconchoidial. If there is no regularity in the break, the break is said to be uneven; if the break is smooth and regular, it is said to be even. A fracture with a very jagged surface is termed hackly, while a fracture showing fibers or splinters is termed fibrous or splintery.

A mineral through which an object can be distinctly seen is called transparent, and one through which no light is transmitted is termed opaque.

Color is the kind of light transmitted or reflected. Often great differences of color are found in a single mineral. The color of a metallic mineral is far more uniform than that of a non-metallic mineral. While the surface color of a mineral may vary from one specimen to another, the color of the powdered mineral does not change. The color of a mineral when it is powdered is known as its streak and may vary considerably from its surface color. In determining the streak, the mineral may be crushed to a powder with a hammer, scratched with a knife blade, or rubbed on a streak plate (unglazed porcelain).

The luster of a mineral is its appearance in ordinary reflected light. Metallic minerals possess that brilliant shine so characteristic of minerals and are said to have metallic luster. Non-metals lack this shine and are said to have non-metallic luster.

Adamantine luster is that peculiar, bright flash so characteristic of diamonds. Vitreous luster is the surface reflection shown ideally by broken glass of which quartz is a good example. Resinous or waxy luster is that kind of surface reflection exhibited by the fossil resins. Pearly luster refers to the shine in mother of pearl. If a mineral shows no luster, it is said to be dull.

Fluorescence is another phenomena observed in minerals. When invisible, ultraviolet rays fall on certain minerals, the rays are transformed and visible light is emitted. Phosphorescence is another property of certain minerals which differs from fluorescence in that the emission of light continues after the exciting rays have been shut off.

Iridescence occurs when white light falling on a specimen is broken up into the rainbow colors of which light is composed. Tarnish differs from iridescence in that it is produced by the permanent alteration of the surface creating a new surface color. For example, silver is often tarnished black.

As illustrated by the opal, opalescence is a milky reflection from within a mineral.

Specific gravity is the weight of an object in relation to the weight of an equal volume of water. This can be determined by weighing the object first in air and then when suspended in water. For example:

Weight in air = 48 grams Weight in water = 32 grams Loss of weight = 16 grams
48/16 = 3 (the specific gravity of the unknown)

In general, metals are conductors of electricity, and most of the non-metallic minerals are non-conductors of electricity. Some minerals, like quartz, show the piezoelectric effect in that electrical charges are produced on the quartz when pressure is applied. Other minerals show the pyroelectric effect in that positive and negative electrical charges are produced on opposite ends of the crystal when the crystal is heated.

Only a few minerals are magnetic but when present, this property is very diagnostic. Magnetite and pyrrohotite are both attracted to a magnet. Lodestone, a variety of magnetite, exhibits remarkable magnetism.

A very large majority of all minerals are found in crystals. A crystal is a body formed by an element or compound solidifying so that it is bounded by plane surfaces, symmetrically located, which are the external expressions of a definite internal arrangement of the atoms of which it is built.

Crystals are classified into six systems. The classification of crystals depends upon imaginary lines called "axes" which are assumed to always pass through the center of the crystals. The differences between the systems are in the number, length, and position of these axes.

1. Crystals which have three axes of the same length and at right angles to each other belong to the isometric crystals. The types of isometric crystals are listed in the outline.

2. The tetrazonal crystal has three axes at right angles to each other with the vertical axes being either shorter or longer than the two equal length horizontal axes.

3. Those crystals with three unequal axes at right angles to each other are called orthorhombic. Sulfur is a good example of this type.

4. Monoclinic crystals have three unequal axes, two of which are at right angles with the third inclined to the other two. The monoclinic is one of the largest mineral crystal systems.

5. A triclinic crystal forms along three unequal axes, some of which are at right angles. There are few minerals which crystallize in this manner.

6. Hexagonal crystals have four axes, three of these axes are horizontal and of equal length forming equal angles with each other, while the fourth is vertical and either longer or shorter than the others and at right angles to them.

Minerals are called gems when they can be cut and polished to make ornaments. Gems can also be defined as a special group of minerals lifted to a place of high value by fashion which makes the most of their natural beauty and scarcity. If the gems are rare and expensive, they are termed precious. Gems have a strong luster, reflect light, and sparkle brilliantly. Reds, greens, yellows, and blues are typical gem colors. Gems have a high index of refraction; therefore, light rays passing through them are bent strongly producing many beautiful colors.

Diamonds are the hardest minerals known and are usually four-sided pyramids. They are commonly used as jewels but are frequently used in industry for cutting and drilling because of their hardness.

Blue corundum minerals are known as sapphires, and red ones are called rubies. The best sapphires come from Ceylon and India while the best rubies come from Burma. The value of these gems depends on the size, color, and freedom from flaws. A perfect ruby is worth about three times as much as a perfect diamond of the same size.

The beryl gems are complicated oxides of beryllium, aluminum, and silicon. When beryl is a bright, clear green, it is known as an emerald which is also more valuable than a diamond.

It is highly probable that billions of years ago, the temperature was so high that the materials of the earth existed in a molten state. As the earth cooled, those substances with the highest cooling point solidified. Such solids, if light enough, would float on the surface and form the crust of the earth.

Rock is any naturally formed aggregate or mass of mineral matter, whether or not coherent, constituting an individual part of the crust.

Igneous rocks are those that have solidified from molten magma. If the magma was extruded over the surface of the earth and cooled quickly before crystals had a chance to form, the rock has a glassy texture. Obsidian is a good example. Often gas bubbles are trapped in the magma; and if the magma cooled before all the bubbles could escape, a frothy or pitted type of rock is formed. Pumice is an example. Those rocks that cool on the surface are classified as extrusive, igneous rocks and are characterized by their small crystals because of the fast cooling. Those that cool inside the crust have large crystals and are called intrusive.

Sedimentary rocks are formed by several processes involving various steps. In all processes, the parent material must be broken down by weathering, either chemical and/or physical. The material is then transported by wind, water, or glaciers to an area where it is deposited. Deposition may be a mechanical process where the carrying agent loses its carrying ability, and the material is simply dropped to form layers. Deposition of material can also occur by the formation of precipitates that sink to the bottom or by the evaporation of inland seas or lakes whereby the dissolved materials form in a layer at the bottom of the lake.

The actual formation of the rock is caused by solidification of the loose sand, clay, shells, and similar deposits due to pressure of overlaying strata and the infiltration of cementing materials. Compaction of carbonaceous deposits of plants also give rise to sedimentary rocks.

Pyroclastic rock is a type of igneous rock associated with explosive volcanic eruptions. They cannot be classified as an igneous rock because of their tendency to mix with other rock material and settle in layers. This process creates a combination of igneous and sedimentary rock.

Metamorphic rocks are changed rocks created by the effect of heat, pressure, and infiltration of gases or water and chemical action on igneous and sedimentary rocks. They usually possess a banded structure (gneiss or schist) or are massive rocks, such as marble which is re-crystallized limestone.

Some of the common metamorphic rocks and the rocks from which they might be derived are: gneiss or quartzite from conglomerate or sandstone, gneiss or schist from granite, schist from basalt, gneiss or schist from gabbro, schist from serpentine, marble from limestone, and slate from shale.

The distribution of many minerals is dependent largely upon the type of rock that is present. For example, oil and natural gas are found mostly in sandstone or limestone which were formed underwater. Salt and borax were formed by the evaporation of lakes. Ores may be formed by underground water, cooling of rocks, contact metamorphism, and hydrothermal solutions. Gold, diamonds, silver, copper, chromite, and cassiterite are found primarily in igneous rocks. Many of the harder materials are found in metamorphic rocks and include such things as slate, marble, anthracite coal, and garnets. The above is a generalization, and there are exceptions to these statements. However, it would probably prove more fruitful to search for oil in sedimentary formations than it would to look for oil in igneous rock.

A mineral from which a metal can be extracted profitably is called an ore. Unless ores are rich in metals, they are usually concentrated by physical means before the metals are extracted.

Ores can be concentrated by a process called flotation. In this process the crude ore is crushed and ground to a fine powder. It is then mixed with water and oil and agitated vigorously. The oil used in the process adheres to the metallic ore but not the non-metallic gangue or waste. The oil being lighter than water floats to the top carrying the metallic ore with it.

Sulfide and carbonate ores are usually roasted to convert them into the corresponding oxides.

In extracting a metal from a concentrated ore, the ore may be smelted, reduced by electrolysis, or reduced with aluminum. The alkali metals, such as sodium and potassium, are usually electrolyzed from their water solutions. The metals less active than aluminum can be freed from their ores by the use of aluminum. The most common method of winning metals from their ores is to "smelt" the ores by reducing them with carbon, carbon monoxide, or hydrogen.

It is obvious that the United States must increase or, at best, maintain its supply of minerals if it intends to remain an affluent society. How are we going to cope with the problem of non-renewable mineral resources in the future?

Many experts agree that new technology of treatment and extraction will prevent the United States from ever becoming mineral resource poor. However, incentives for radical innovation in technology are now lacking since mineral deposits in other parts of the world can be profitably developed. Therefore, investment capital is attracted abroad, and the import-export deficit widens. Capital will continue to flow to those countries with lower labor costs, greater government incentives, and minimum costs of pollution control as well as high-grade ores which can be readily exploited by well-established procedures and available equipment.

Another consequence of the United States increasing its imports of mineral resources has been a rather low activity of exploration for mineral deposits at home and only low level activity to attack research in improving technology. We tend to be comfortable with the thought that in case of an emergency due to a cut off of foreign imports, our scientists will "fix it".

Many wants of the world are not presently caused by lack of minerals and fuels but by lack of economic resources to buy what is available and for lack of organization and training to use what is available.

The major unknown concerning future availability of resources on a world-wide basis is the impact of increasing population and demand sure to come but unknown as to extent.

The major hope of mankind to meet this challenge of unknown magnitude is through technological improvement.

Minerals so far used by man have come from near the surface. We need to learn how to explore deeper, cover surface ground more rapidly, increase use of computers, and extract minerals from under the sea if we are to meet future needs.

Another conservation procedure is and will be in "mining" our junkyards. Forty per cent of our lead and twenty-five per cent of our copper for 1968 will come from reclaimed scrap. However, we are not reclaiming all that we could. For the present, our city dumps are lost resources as are the so called "sanitary land fills". The thirty-four million metric tons of municipal waste incinerated in this country contain more than 2.8 million metric tons of iron and approximately 180,000 metric tons of aluminum, zinc, copper, lead, and tin. In addition to being wasted, the burning of these materials adds to the air pollution problem.

Minerals may be preserved by finding substitutes and by finding technically better materials to do a particular job. Examples of substitution include using plastic in place of steel for automobiles, in place of wood and paper for packaging, and in place of copper tubing and using aluminum in place of steel and copper.

OUTLINE OF CONTENT MATERIAL

- I. Introduction to Minerals
  - A. Definition.
  - B. Origin.
  - C. Concentration.
  - D. Supply.
  - E. General composition.

- II. Classification of Minerals
  - A. Chemical composition as a basis (anionic groups).
    - 1. Halides.
      - a. Chemical composition.
      - b. Characteristics.

        Examples: Fluorite, halite.
    - 2. Silicates.
      - a. Chemical composition.
      - b. Characteristics.

        Examples: Quartz, feldspar.
    - 3. Oxides and hydroxides.
      - a. Chemical structure of oxygen.
      - b. Characteristics.

        Examples: Uraninite, hematite, limonite.
    - 4. Sulfides.
      - a. Chemical structure of sulfur.
      - b. Characteristics.

        Examples: Galena, pyrite.
    - 5. Carbonates.
      - a. Chemical composition.
      - b. Characteristics.

        Examples: Calcite, dolomite.
    - 6. Phosphates.
      - a. Chemical composition.
      - b. Characteristics.

        Example: Phosphorite.
    - 7. Sulfates.
      - a. Chemical composition.
      - b. Characteristics.

        Example: Gypsum.
    - 8. Arsenates and vanadates.
      - a. Chemical composition.
      - b. Characteristics.

Examples: Erythrite, annabergite (arsenates).
Vanadates (vanadates).

9. Native elements.
    Examples: Copper, gold, silver.

B. Mineral fuels.
  1. Coal.
      a. Peat.
      b. Lignite.
      c. Bituminous.
          1. Formation.
          2. Production of coke.
          3. Economic importance.
              a. Employment.
              b. By-products.
      d. Anthracite.
          1. Formation - compared to bituminous.
          2. Mined only in northeastern Pennsylvania.
          3. Limited in supply when compared to bituminous.
  2. Petroleum.
      a. History.
          1. First oil well - Drake (1859).
          2. Titusville, Pennsylvania.
          3. First used for making kerosene.
          4. Acceleration of use with development of automobile.
      b. Areas of oil production in the United States.
          1. Pennsylvania.
          2. Texas and Oklahoma.
          3. California.
          4. Gulf states and off-shore oil.
      c. Waste in early production.
      d. Important by-products.
      e. Other sources of oil.
          1. Shale.
          2. Coal.
          3. Sand.
  3. Natural gas.
      a. Characteristics.
      b. Abundant supply.
      e. Ideal fuel to combat air pollution.

C. Metals.
  1. Iron ore.
      a. Production of iron.
      b. Uses of iron.

        - c. Mesabi Range.
        - d. Important in the history of our industrial society.
    - 2. Copper.
        - a. Production of copper.
        - b. Mined in approximately half-dozen states.
        - c. Uses of copper.
        - d. Great increase in its use due to use in electrical equipment.
        - e. Can be reused.
    - 3. Gold.
        - a. Gold rush.
            - 1. California.
            - 2. Nevada.
            - 3. Black Hills
            - 4. Klondike (Alaska).
        - b. Unimportant factor as an industry.
        - c. Standard for currency.
    - 4. Silver.
        - a. Significant in "opening the West".
        - b. Free coinage: 1880 to 1900.
        - c. Uses.
            - 1. Mining.
            - 2. Photography.
            - 3. Tableware.
    - 5. Aluminum.
        - a. One of the most abundant elements.
        - b. Gradually replacing other metals.
    - 6. Zinc.
    - 7. Tin.
    - 8. Lead.
- D. Non-metallic.
    - 1. Sulfur.
    - 2. Graphite.
    - 3. Gypsum.
    - 4. Halite.
    - 5. Borax.
    - 6. Fluorite.
    - 7. Talc.
    - 8. Asbestos.
    - 9. Potash.
    - 10. Phosphorus.
    - 11. Limestone.
    - 12. Salt.

III. Identification of Minerals
A. Hardness.
1. Mohs scale of hardness.
2. Testing procedure.
a. Set of ten minerals.

Mineral	Hardness
1. Talc	1
2. Gypsum	2
3. Calcite	3
4. Fluorite	4
5. Apatite	5
6. Orthoclass	6
7. Quartz	7
8. Topaz	8
9. Corundum	9
10. Diamond	10

b. Common substitutes for the above scale.

Material	Hardness
1. Fingernail	2.5
2. Penny	3
3. Plate glass	3.5
4. Knife blade	5.5
5. Steel file	6.5

B. Tenacity.
1. Definition.
2. Kinds.
a. Malleability.
b. Ductility.
c. Brittleness.
d. Flexibility.
e. Elasticity.
f. Sectile.
C. Cleavage.
1. Definition.
2. Types.
a. In one direction (basal) - mica.
b. In two directions at right angles - feldspar.
c. In two directions not at right angles - amphibole.
d. In three directions at right angles (cubic) - galena.
e. In three directions not at right angles (rhombohedral) - calcite.
f. In four directions (octahedral) - fluorite.

- D. Fracture.
    - 1. Definition.
    - 2. Types.
        - a. Even.
        - b. Uneven.
        - c. Conchoidial.
        - d. Subconchoidial.
        - e. Splintery or fibrous.
        - f. Hackly.
- E. Effect of light upon minerals.
    - 1. Transparency.
    - 2. Color.
    - 3. Streak.
    - 4. Luster.
        - a. Metallic.
        - b. Non-metallic.
        - c. Adamantine.
        - d. Vitreous.
        - e. Resinous.
        - f. Pearly.
        - g. Silky.
        - h. Dull.
    - 5. Refraction.
    - 6. Fluorescence.
    - 7. Phosphorescence.
    - 8. Iridescence.
    - 9. Tarnish.
    - 10. Opalescence.
- F. Specific gravity.
    - 1. Definition.
    - 2. Calculations.
- G. Electrical and magnetic.
    - 1. Piezoelectric effect.
    - 2. Pyroelectric effect.
- H. Crystals.
    - 1. Nature of crystals.
    - 2. Crystal systems.
        - a. Isometric crystals.
            - 1. Cube (halite).
            - 2. Octahedron (diamond).
            - 3. Dodecahedron (granite).
            - 4. Trapezohedron (leucite).
            - 5. Pyritohedron (pyrite).

b. Tetragonal crystals.
Examples: Chalcopyrite, cassiterite.
c. Orthorhombic crystals.
Examples: Topaz, bauxite, stibnite.
d. Monoclinic crystals.
Examples: Borax, selenite, malachite.
e. Triclinic crystals.
Example: Amazonstone.
f. Hexagonal crystals.
Example: Beryl.
I. Flame test.
J. Bead tests.
K. Tube test.
L. X-ray diffraction.
M. X-ray fluorescence.
N. Infra-red spectroscopy.

IV. Gems
A. Definition.
B. Properties.
C. Classification.
1. Precious.
2. Semi-precious.
D. Common gems.
1. Diamonds.
2. Corundum.
a. Sapphire.
b. Ruby.
3. Beryls - emeralds.
E. Uses.

V. Rocks
A. Comparison to minerals.
B. Classification.
1. Igneous.
a. Formation.
b. Types.
1. Intrusive.
a. Large crystals.
2. Extrusive.
a. Very fine crystals.
b. Basalt.
c. Pumice.

2. Sedimentary (secondary in origin).
  a. Formation.
    1. Delta.
    2. Strata.

Common examples: Sandstone, shale, limestone.

3. Pyroclastic.
  a. Formation.
  b. Combinations.
4. Metamorphic.
  a. Formation.
  b. Examples.
    1. Slate from shale.
    2. Quartzite from sandstone.
    3. Marble from limestone.

C. Materials (per cent composition).
  1. Silica - 60%.
  2. Lime - 5%.
  3. Alumina (clay and muds) - 15%.

D. Beds.
  1. Formation.
  2. Folds.
    a. Dip.
    b. Strike.
    c. Outcrop.
    d. Anticline.
    e. Syncline.
    f. Faults.
    g. Joints.

E. Movements.
  1. Diastrophism.
  2. Theories of earth movement.
    a. Isostasy.
    b. Contraction.
    c. Convection.
    d. Continental drift.
    e. Earth expansion.
    f. Sea-floor spreading.

F. History of rock.
  1. Superposition of rock.
  2. Unconformity.
  3. Age of rock.
    a. Radioactive dating.
    b. Fossils.

        - c. Magnetic polarity.
    - 4. Geological times.
        - a. Precambria era.
        - b. Palezoic era.
            - 1. Cambria period.
            - 2. Ordovician period.
            - 3. Silurian period.
            - 4. Devonian period.
            - 5. Carboniferous period.
                - a. Mississippian.
                - b. Pennsylvanian.
            - 6. Permian period.
        - c. Mesozoic era.
            - 1. Triassic period.
            - 2. Jurassic period.
            - 3. Cretaceous period.
        - d. Cenozoic era.
            - 1. Tertiary period.
            - 2. Quaternary period.

VI. Distribution of Minerals
- A. In relation to rock structure.
- B. Geographical.

VII. Minerals in History
- A. Wars.
- B. Civilizations.
    - 1. Stone age.
    - 2. Bronze age.
    - 3. Iron age.
    - 4. Steel age.
    - 5. Age of plastics.
    - 6. Nuclear age (uranium ores).
- C. Colonization.

VIII. Utilization of Minerals and Rocks
- A. Ore.
    - 1. Definition.
    - 2. Methods of concentrating ores.
        - a. Flotation.
        - b. Roasting.
        - c. Magnetic concentrations.
        - d. Chemical concentrations.

    3. Methods of freeing material from ores.
        a. Smelting.
        b. Electrolysis.
        c. Use of aluminum (thermite reduction).
B. Fuels.
    1. Coal.
    2. Petroleum.
    3. Oil shale.
    4. Natural gas.
C. Metals.
D. Building materials.
E. Fertilizers.
F. Raw materials for chemical industry.
G. Raw materials for glass.
H. Raw materials in the ceramic industry.
I. Water purification.
J. Jewelry industry.
K. Production of soil.
L. Nutrients for plants and animals.

IX. Conservation of Minerals
    A. Reuse (scrap metals).
    B. Substitutes.
        1. Plastics for metals.
        2. Wind, tides, and waterpower for generating electricity.
        3. Alcohol for gasoline engines.
        4. Electric automobiles.
        5. Solar energy for heating buildings.
    C. More efficient mining methods.
        1. Deeper mining.
        2. Use of low-grade ores.
    D. Finding new sources and ways of harvesting.
        1. Oceans - one cubic mile contains:
            a. 81,000,000 tons of chlorine.
            b. 43,000,000 tons of sodium.
            c. 5,600,000 tons of magnesium.
            d. 280,000 tons of bromine.
            e. 200 tons of iodine.
            f. 2 tons of uranium.
            g. 57 pounds of gold.
            h. Plus many other minerals of economic importance.
    E. Synthetics - diamonds, rubies, quartz.

LEARNING ACTIVITIES AND MATERIALS

I. Learning Activities

A. Demonstrations.

1. Test a mineral containing copper by first crushing a bit of the mineral to a powder. Dip a test wire in an acid and then touch the powdered mineral with the wire. Place the wire in a flame and note the blue-green color.
2. Test a copper mineral by dissolving it in hydrochloric acid. Then dilute the acid solution with water and add ammonium hydroxide drop by drop. A dark blue complex ion of copper should result.
3. Heat some powdered mineral of iron in a test tube with concentrated hydrochloric acid. Dilute the resulting solution with an equal volume of water and then add ammonium hydroxide drop by drop. A rust-red precipitate of ferric hydroxide indicates the presence of iron.
4. Dissolve a mineral containing lead in dilute nitric acid and dilute the resulting solution with water. Add a drop of sodium iodide. A bright yellow precipitate of lead iodide indicates the presence of lead..
5. Dissolve a mineral containing zinc in hot hydrochloric acid and then add a few drops of potassium ferrocyanide. A light blue precipitate indicates zinc.
6. Using a platinum wire, perform tests on solutions of various minerals by placing the wire in the solution and then in a flame. Use a blue glass to view the results since the yellow sodium color may mask any other colors present (flame test).
7. Test many minerals under ultraviolet light for the property of fluorescence. (An inexpensive light is the argon bulb.)
8. Heat a tourmaline crystal and determine if any electrical charges are present by bringing the crystal toward small bits of paper.
9. Magnetize a knife blade by rubbing it on a piece of lodestone.
10. Grow salt crystals from a salt solution as follows: Dissolve several small pieces of halite (rock salt) in a pyrex beaker with boiling water. Hang a string on the edge of the glass so that half of the string hangs inside the salt-water solution and the other half outside. Place the glass near a hot register for several days and then observe the salt crystals which form.
11. Using a Geiger Counter, determine whether minerals are radioactive.
12. Prepare an autoradiograph of some uranium minerals as follows: Wrap a sheet of unexposed photographic film in black paper and place in a light-tight black envelope. This must be done in a dark room. Place a piece of a radioactive mineral of uranium in the envelope and leave for twenty-four hours. Develop the film and observe the results.
13. Watch ice crystals grow by placing a mirror in the bottom of a pan of water. Set the pan where it will cool to a temperature below freezing. Ice crystals

will soon form in the pan where they can be watched in the mirror.

14. Determine the north and south poles of a piece of lodestone by dipping it into some iron filings. The filings will cling most tightly to the lodestone at its poles.
15. Determine the specific gravity of a mineral by weighing the specimen in air. Next suspend the specimen in water and weigh it again. Subtract the weight in water from the weight in air. Divide the loss of weight in water into the weight in air to find specific gravity.
16. Mold clay into a three- or four-inch ball. Place the clay ball into the sunlight for one hour. Next, place the clay in the shade for five minutes. Record the temperature on the surface of the clay ball. Place the thermometer inside the clay ball and record this temperature. Compare the two temperatures.
17. Place two ice cubes on a table. Place a brick that has been chilled in a freezer on top of one ice cube and nothing on top of the other ice cube. Which ice cube melts faster? Why? How does this apply to temperature and pressure under the earth's crust?
18. Test rocks for the presence of calcite (limestone) by dropping dilute hydrochloric acid on them. The presence of bubbles fizzing indicates calcite is present.
19. Secure a streak plate (unglazed porcelain tile) and test various minerals for their streak (the color of the powdered mineral).
20. Using a set of minerals in the Mohs scale of hardness, test several minerals to determine their hardness.
21. Place a small amount of the mineral galena, lead sulfide, into a depression made in a charcoal block. Heat the galena slowly with a mouth blowpipe flame until it changes into a metallic globule of lead. Test the resulting lead to determine if it is malleable.
22. Collect various minerals and demonstrate the different characteristics of minerals, such as: luster, cleavage, fracture, and magnetism.

B. Field trips.
   1. To a museum to observe and study mineral specimens.
      a. U. S. Bureau of Mines, Pittsburgh, Pennsylvania.
      b. Carnegie Museum, Pittsburgh, Pennsylvania.
      c. Department of Mineral Industries, Pennsylvania State University.
   2. To a rock quarry.
   3. To an iron and steel plant to study the operation of a blast furnace.
   4. To study and collect the common rocks and minerals in your area.
   5. To the sites of old mines which have been sealed against mine acid drainage and to those where mine acid drainage is occurring. Compare the two sites as to water, plants, and animals found in the area.
   6. To a road cut or strip mine to study rocks, minerals, and various strata.

7. To various industries in your area to see how minerals are used in the production of various items.
8. Visit the local filling station, obtain the name of the company from which the owner receives his oil products, and have one class member write the company for literature on the source, refining, and distribution of oil.

C. Discussion.
   1. What do you think would happen to our seacoasts if all the glaciers melted?
   2. How do we use limestone?
   3. What is an alloy?
   4. What are the common rock-forming materials?
   5. What minerals were used by man during the bronze age? The stone age? The iron age?
   6. Should fluorides be added to drinking water? Explain your reasons.
   7. Where do we secure our tin? Iron? Nitrates? Nickel? Gold? Phosphates? What do we use them for?
   8. Why are coal and petroleum never found in igneous and metamorphic rocks?
   9. What minerals are commonly used in agriculture? What effect does each one have?
   10. How might we conserve our petroleum supply? Our silver supply? Our iron supply? Our copper supply?
   11. What is a rock? A mineral? An element?
   12. What are zeolites?
   13. How is coal, natural gas, and petroleum formed?
   14. How might stripped areas be reclaimed? Who should pay for this?
   15. How much coal (per capita) do we use each year? How much natural gas? How much petroleum?
   16. What makes minerals different from other resources?
   17. Why is gold considered more precious than copper?
   18. How are minerals needed in the use of other natural resources (soil, water, forests, wildlife, and recreational resources)?
   19. Compare the slowness of mineral formation with the speed of present day use.
   20. Discuss the rate of mineral consumption during war time in relation to consumption during peace.
   21. Discuss the role of minerals in the early and present development of Pennsylvania.
   22. What sources of energy may supplement the mineral fuels?

D. Bulletin board displays.
   1. Minerals used in agriculture.
   2. Minerals used in industry.
   3. The per cent composition of the crust of the earth.
   4. Minerals used in making jewelry.
   5. Minerals present in the sea.

6. Map of the county and state showing mineral deposits.
7. Common rocks used in home construction.
8. Classification of minerals by metals and non-metals.
9. Posters to show how strip mine areas should look when restored.

E. Student activities and projects.
   1. Make a pictograph showing the many representative products which are made from aluminum.
   2. Make a pictograph showing the many useful products made from asbestos.
   3. Join a rock and mineral club or organize a club if one does not already exist in your area.
   4. Collect articles concerning minerals from newspapers and magazines.
   5. Make a survey of the minerals found in your area, county, and state.
   6. Collect rocks from your locality. Examine and classify each rock for color, smoothness or roughness, texture, grain, etc.
   7. Obtain samples of minerals. Identify them by various tests and characteristics mentioned in the outline and demonstrations.
   8. Study a sample of sediment and discover its composition. Use graph paper with millimeter squares to classify the sand particles by size. Identify as many of the particles as you can.
   9. Make a scale model of a valley in your area.
   10. Heat a small piece of shale for two or three minutes. Then quickly dip it into cold water. Relate this to the weathering process found in nature.
   11. Collect samples of the different kinds of coal.
   12. Determine the specific gravity of a rock sample.
   13. Test common minerals with a magnet and see which ones possess magnetism.
   14. Grow chemical crystals in a jar.
   15. Plan a scrap metal drive. Collect old metals and sell them.
   16. Figure how much it costs to heat your home. What economical practices might be started which would conserve some of the fuel you are now using?
   17. Explore the school, and list the kinds of minerals used in the building.
   18. Visit the local fertilizer dealer and obtain samples of various fertilizers, literature on the ingredients of each, and the source from which it came.
   19. List and describe the new, useful minerals discovered since 1950.
   20. Obtain as many kinds of minerals as you can and place them in the three major groups--mineral fuel, metallic, and non-metallic.

II. Learning Materials
   A. Audio-visual materials.
      1. See list of sources at the end of the guide.
   B. Books and pamphlets.
      1. Adams, Frank Dawson, The Birth and Development of the Geological Sciences, Dover Publications, Inc., New York, 1954.

2. Amstutz, G. C., "Sedimentology and Ore Genesis", *Developments in Sedimentology*, Vol. 2, Elserier, 1964.
3. Bateman, A. M., *Economic Mineral Deposits*, 2nd Edition, Wiley, 1950.
4. Bates, R. L., *Geology of the Industrial Rocks and Minerals*, Harper, 1960.
5. Booth, Verne H., *Physical Science*, 2nd Edition, MacMillan Company, New York, New York, 1962.
6. Brooks, D. B., *Supply and Competition in Minor Metals*, The Johns Hopkins Press, 1965.
7. English, G. L. and Jensen, D. E., *Getting Acquainted with Minerals*, (revised edition), McGraw-Hill Book Company, Inc., New York, 1958.
8. Feiss, J. W., "Minerals", *Scientific American*, pp. 128-136, September, 1963.
9. Fenton, Carroll Lane and Fenton, M. A., *Riches from the Earth*, The John Day Company, New York, 1953.
10. Flawn, P. T., *Mineral Resources*, Rand McNally & Company, 1966.
11. Herfindahl, O. C., *Three Studies in Mineral Economics*, Resources for the Future, Inc., 1961.
12. Hibbard, W. R. Jr., "Mineral Resources: Challenge or Threat"?, *Science*, Vol. 160, pp. 143-149, April, 1968.
13. Jensen, David E., *Collecting Rocks and Minerals*, Hart Book Company, Inc., Chicago, 1955.
14. Landsberg, H., *Natural Resources for United States Growth*, The Johns Hopkins Press, 1964.
15. Landsberg, H. H., Fischman, L. L., and Fisher, J. L., *Resources in America's Future*, The Johns Hopkins Press, 1963.
16. Leet, L. D. and Judson, S., *Physical Geology*, 3rd Edition, Prentice-Hall, 1965.
17. Lindgren, W., *Mineral Deposits*, 4th Edition, McGraw-Hill, 1933.
18. Mason, B. and Berry, L. G., *Elements of Mineralogy*, W. H. Freeman & Company, 1968.
19. *Materials*, A Scientific American Book, W. H. Freeman & Company, 1967.
20. McDivitt, J. F., *Minerals and Man*, The Johns Hopkins Press, 1965.
21. Mero, J. L., *The Mineral Resources of the Sea*, Elserier, 1965.
22. *Mineral Facts and Problems*, Bulletin 630, Bureau of Mines, U. S. Department of Interior, 1965 Edition.
23. Park, C. F. and MacDiarmid, R. A., *Ore Deposits*, W. H. Freeman & Company, 1964.
24. Pearl, R. M., *How to Know the Minerals and Rocks*, McGraw-Hill, 1955.
25. Pearl, R. M., *Geology - College Outline Series*, Barnes & Noble, Inc., New York, New York, 1960.
26. Pough, F. H., *A Field Guide to Common Rocks and Minerals*, Houghton Mifflin Company, Boston, Massachusetts, 1960.

27. Ramsey, W. L. and Burckley, R. A., Modern Earth Science, Holt, Rinehart & Winston, Inc., New York, New York, 1961.
28. Reinfeld, Fred, Rocks and Minerals, Sterling Publishing Company, Inc., New York, 1954.
29. Riley, C. M., Our Mineral Resources, Wiley, 1959.
30. Rogers, J. J. W. and Adams, J. A. S., Fundamentals of Geology, Harper & Row, 1966.
31. Schanz, J. J., Historical Statistics of Pennsylvania's Mineral Industries, 1759-1955 and 1956-1960, College of Mineral Industries, Bulletins 69 and 70, 1957 and 1963.
32. Spock, L. E., Guide to the Study of Rocks, Harper & Brothers, New York, New York, 1953.
33. Zim, H. S. and Shaffer, P. R., Rocks and Minerals, A Golden Nature Guide, Simon & Shuster, New York, New York, 1957.
34. Zim, H. S. and Cooper, E. K., Minerals, Harcourt, Brace & World, Inc., New York, 1943.

SOIL

BACKGROUND INFORMATION

It may be difficult to glamourize but impossible to overemphasize the importance of soil to mankind. Either directly or indirectly, it is the principle source of our food and clothing; it furnishes many of the raw materials needed in industry, in construction, and in transportation; and finally, it has a stabilizing influence on water, plants, and animals.

Attempting to define soil with one definition is almost impossible because there are thousands of kinds of soil, and each one has its own unique characteristics and history. The following are a few of the accepted definitions of soil:

1. Soil is the zone of complex chemical, biological, and physical processes constantly in action--a dynamic layer capable of change and development.

2. Soil is the life-giving layer which supports all forests, grasslands, and crops and from which the animal life of the lands derives its food.

3. Soil refers to the surface layer a few inches or feet thick which has developed distinctive layers or horizons and which has the necessary physical, chemical, and biological properties to sustain plant life.

4. Soil is the loose surface material of the earth in which plants grow.

Soil is a renewable natural resource. Nature can and does produce new soil, but it is a very slow process.

The soil is divided into layers or horizons depending on the content, structure, and biological activity found in each layer. These layers include the topsoil, subsoil, and bedrock. The topsoil or horizon A is the uppermost layer and is composed of coarse mineral particles and partially decomposed organic matter. It is an area of maximum biological activity and can support plant growth.

Subsoil, composed of horizons B and C, contains less organic matter and smaller mineral particles. There is very little biological activity in these layers and their ability to support plant growth is very limited.

Horizon D, either bedrock or unconsolidated materials, is the bottom layer of soil and serves as the parent material for the other horizons.

Fertile soil contains (1) rock particles, (2) humus, (3) water, and (4) air--all in varying proportions.

The rock particles supply the minerals or nutrients needed for plant growth. The major elements obtained from the soil include:

Nitrogen, in conjunction with other elements, causes green coloring, produces rapid growth, and causes the development of leaves, stems, and fruit. Nitrogen increases the protein content and leaf quality of many crops.

Calcium is important to plant growth. It serves as a food for the plant and as an acid neutralizer.

Phosphorus is available to the plant in the form of phosphates. A deficiency of phosphorus limits cell division and causes late maturity, deformed growth, incomplete seed formation and development, and weak root development.

A lack of potassium results in unnatural color in certain crops, a lack of winter hardiness in legumes, and weak and shriveled grains.

Magnesium and sulfur are important for good plant growth.

Trace elements, as shown in the outline, are those found and needed by plants in minute amounts. However, a deficiency of any of these elements will cause as serious a problem as a deficiency of any of the major elements.

Humus, which is decayed organic matter, acts as a sponge to retain water in the soil and to release various minerals as it decays.

Water is essential for life and serves as one of the raw materials used to build protoplasm. It is a solvent in which the minerals may be dissolved thus permitting entry into the roots of the plants. Minerals and nutrients must be in a solution to enter the root system of plants. Water held tightly to the soil particles in a very thin layer is called hydroscopic water and is not available for plant use. Capillary water is held to the soil particles in a quantity that will move about in the soil and consequently provide moisture for plants. Free or gravitational water moves freely downward and is available for plant use for a limited period of time.

The oxygen needed for respiration by the plants and animals in the soil is provided by the air from the atmosphere that is found in the pores of the soil.

The living micro-organisms found in the soil decompose the dead organic matter releasing the nutrients for reuse by the plants. Larger animals, such as earthworms, help keep the soil loose and porous and, thereby, allow more air and water to circulate through the soil. The roots of larger plants help to hold the soil in place. Of special importance are the nodules found on the roots of legume plants (alfalfa, soybeans, etc.).

These nodules provide a home for nitrogen-fixing bacteria that have the ability to take free nitrogen (an unusable form for plants) from the atmosphere and convert it to a usable form for the plants.

In attempting to classify and describe soils, pedologists (soil scientists) have devised three orders of soils. Soil developed over extensive areas under conditions of good drainage during a sufficient length of time to develop distinct horizons are referred to as the zonal order of soils. The intrazonal order consists of soils developed in areas of poor drainage, such as meadows and bogs of humid climates and on flat upland surfaces. The azonal order has no distinctive physical characteristics, such as horizons, because they are immature or lie on slopes too steep to permit profile development.

Using texture as a basis of comparison, there are four general soil types. The texture of a soil is important because it determines the rate at which water will drain through the soil and the amount of water that will be retained or stored by the soil. The different texture of soils is covered in the outline and no further information is needed here except to note that loam soil is the best for most plants because it has the good characteristics of both clay and sandy soils. Clay soils tend to absorb and hold large quantities of water which make them very wet. Also, their small soil particle sizes tend to cause compression. With larger soil particles, sandy soils tend to be very porous with poor water absorbing qualities. Hence, they are usually dry and loose.

Climatic conditions under which the soils develop also influence the type of soil that will be formed.

Podzolic soils develop in cool, humid forest areas in the higher latitudes of the northern hemisphere and in a few areas in the southern half of the world. These soils are commonly low in bases and organic matter and exhibit pronounced leaching. They are usually not very fertile; however, they are very responsive to soil management practices. Pennsylvania has large areas of gray-brown podzolic soil.

The soils developed in areas of high precipitation and high temperature are referred to as latosolic soils and are found in Central Africa, Central America, Southeast Asia, and northern Australia. Because these soils are strongly weathered and leached to great depths, poor horizon development results. A high concentration of iron usually gives this soil a red or yellow color.

Chernozemic soils develop in areas of grass vegetation in temperate to cool, subhumid regions. They are characterized by a high organic content resulting in a very dark coloring. As a rule, they are very fertile.

Tundra soils develop in high latitudes and cold climates. The climate restricts biological activity and the weathering process causes poor horizon differentiation. The subsoil is permanently frozen and is referred to as permafrost.

A soil that develops under mixed shrubs and grass vegetation in arid climates in the middle and low latitudes is called a desertic soil. This soil is characteristically low in organic content and nitrogen. Since it is slightly weathered and leached, faint and shallow horizons result. However, the nutrient level of this soil is fairly high and with proper management (irrigation), this soil may be the answer to our future land needs.

Within each of these groups are soil classifications referred to as local soils. Basically, all soils will fit into one of the previous categories; but some local variations in climate, precipitation, vegetation, etc. cause small differences among the larger groups. These must be sub-divided into local classifications.

The manner in which soil particles are grouped or clumped together is called structure and is important because it affects the absorption and transmittal rate of water. Granular structure seems to be the best for most plants. This type of structure is characterized by small, spherical particles.

Irregular pieces with sharp corners and edges are called either "blocky" or "lumpy".

Columnar and prismatic structure refers to vertical columns or prisms varying from a fraction of an inch to four feet across.

Horizontal, platelike pieces are characteristic of a soil with a "platy" structure.

The coarse fractions of soils, gravel, sand, and silt act as individual particles and are composed of rock fragment or primary minerals, such as quartz and feldspar, plus other salts, oxides, and hydroxides. Over short periods of time, these fractions serve as relatively inert skeletons where the more reactive constituents are assembled. Clay, the fine fraction of soils, contains collodial oxides, hydroxides, amorphorus silicates, chlorites, micas, and a group of organic compounds and controls most of the important properties of a soil. Most chemical reactions occur on the surface of soil particles. Clay particles are the smallest and the most numerous, thereby offering the most surface area for chemical reactions.

$_pH$ is used to designate the acidity or alkalinity (base) of a material. It is a scale ranging from 1 to 14. A $_pH$ of 7 is neutral indicating a balance of H^+ and OH^- ions. Numbers below 7 indicate a surplus of H^+ ions, and those above 7 indicate a surplus of OH^- ions. The larger the deviation from 7, the stronger the acidity or alkalinity of the material. Thus, a $_pH$ of 1 is very acid in relation to a $_pH$ of 6. Most plants grow best in $_pH$ ranges around 7.

Soil formation is influenced by many factors. The climate of an area, particularly the temperature and the amount and kind of precipitation, influences the rate of weathering and decomposition of organic matter. It exercises indirect control by its control over the type of plants and animals that can thrive in a region. Since climate is so important to soil formation, the broad soil regions of the world tend to follow the distribution of climates. However, soil and climate regions are not identical since other factors are also important in soil formation.

The parent rock, sometimes called a passive factor, must be weathered to form the soil parent materials. These are then further changed as horizons develop in a soil profile. The composition and structure of the rock greatly influence the rate and products of weathering. Pedologists disagree about the extent to which the kind of parent material determines the soil's characteristics. At one time, soil classifications were largely geological in nature; that is, they were divided into two major groups. The residual groups were based on the type of rock from which the soil was developed and the transported groups according to the way in which the materials were deposited. About 1870, Russian pedologists claimed that regardless of what the parent material was, with similar topographic, climatic, and vegetative conditions, and after equal time intervals, the soils produced were essentially the same.

Topography or relief affects runoff and drainage of water and, therefore, affects soil formation. Runoff is large on steep slopes and small on level slopes. Runoff removes weathered rock and soil on steep slopes giving rise to thin and poorly developed soils. It also influences the amount of moisture in the soil by determining the rate of drainage in any particular area.

Biological activity is important chiefly to horizon differentiation. In ideal habitats, the plants become so numerous that they change the nature of the soil itself. When the plants die, they add humus to the soil. This increases the water-holding capacity of the soil and also, as the humus itself decomposes, adds fertility which permits still more luxuriant plant growth. Increased plant growth means a more extensive network of roots underground to absorb water and minerals from the soil. These roots help to hold the soil in place, thus reducing the amount of erosion. Also, plants furnish food and shelter for animals. Abundant plant growth implies the presence of animals. These animals affect the condition of the soil also.

How much time is required for soil formation depends upon when and where the processes must act. No matter where it occurs, it is a slow process. It may form at the rate of one inch every 1,000 years, or it may take as long as several million years.

In his attempt to change the environment to suit his own needs, man influences soil formation. By adding lime, he changes the pH of a soil from acidity to neutral and increases organic content with the application of manure. Addition of commercial fertilizers greatly increases the amount of nitrogen, phosphorus, and potassium. Probably the greatest influence is exerted by the way he uses the soil and the farming methods involved. These methods will be discussed in greater detail in conservation practices.

The actual process of soil formation can be divided into three simultaneous processes. The process whereby the rocks are changed physically from larger to smaller pieces is called physical disintegration. This breaking up of rocks is caused by abrupt temperature changes; rocks expand when heated and contract when cooled. However, the exterior of the rock will change faster than the interior part of the rock. Consequently, a rapid change in temperature causes opposing forces within the rock and creates cracks and fissures. These cracks fill with water which freezes, causing the cracks to enlarge. By alternate periods of freezing and thawing, the rocks are broken down gradually. Abrasion is a further cause of rock disintegration. This is a result of glaciers, wind-blown sand, and pebbles carried by water hitting the rock surface and wearing away small amounts of the parent rock.

Chemical decomposition of rock particles takes place by oxidation, hydration, and corrosion by acids. Oxidation refers to the combining of oxygen from the air with minerals in the rocks. The combination of water with these minerals is called hydration. Carbon dioxide, a by-product of respiration, combines with water to form carbonic acid in the soil. This acid causes corrosion of rocks and other materials and aids in new soil production.

Another phase of soil formation is the addition of humus to the rock particles. In order to be classified as a soil, the rock particles must contain humus.

Soil erosion and soil formation are two sides of the same coin. Both are normally present at the same time on any piece of land. Soil erosion is a tearing down process; soil formation is a building up process. Within limits, both are normal and desirable aspects of nature; but, unfortunately, in many instances man has upset the balance of nature and speeded up the process of erosion by methods listed in the outline.

The first step toward soil erosion is usually biological deterioration. There is a decrease in the amount of organic matter brought about by a decreased number of plants and animals. This is followed by physical deterioration where the soils become more compact with a smoother surface. The granular structure of the soil breaks down resulting in fewer and smaller pores in the soil. Leaching begins to take place at a rapid pace, and mineral content becomes deficient for plant growth. This results in a decline in soil fertility and is called chemical deterioration. Moisture deterioration consists of a lowering of the water table and an inadequate supply of water for plant growth. Because of the compactness of the soil surface, evaporation and runoff are high and the percolation of water into the soil is slow. Finally, erosional deterioration starts. It is caused primarily by water or wind.

Raindrop splash is one of the major factors in water erosion in that it causes structural change in the soil horizons. The force applied to the soil by the raindrops breaks up the soil and makes it more vulnerable to erosion. The magnitude of the eroding force is determined by the size of the raindrops, velocity, and amount of rainfall. Puddle erosion refers to the beating and churning action of these drops on the soil's finely broken parts by forcing them into a nearly impervious layer of surface mud. Fertility erosion refers to the removal of the light organic soil particles by the raindrop splash. The most dangerous form is sheet erosion because it is difficult to detect and attacks only the topsoil in fertile land. It is actually splash erosion where the raindrops wear the soil down evenly over the entire surface of the field.

Runoff water causes gully erosion which, as the name implies, is the formation of gullies in the fields. The determining factors are the amount of water and the velocity with which it leaves the field. The more volume and higher velocity of water, the more erosion it will cause.

Wind, the second agent of erosion, generally erodes soil in areas of light rainfall. Most soil carried by wind is moved in a series of short bounces that is called "saltation". Soil grains moved by saltation are started by eddies which lift them straight up. The forward movement of the wind simultaneously pushes them along until the pull of gravity overcomes the lifting power of the wind. In the "suspension movement", the lifting power of the wind on the fine particles still exceeds the gravitational pull. The particles are lifted higher and are carried along with the wind. Sand grains too heavy to be lifted off the ground by eddies are pushed along the surface by a movement called "surface creep".

The movement of soil particles by the wind is primarily dependent on the force and velocity of the wind. Soil movement depends on the moisture in the soil, the character of the soil, and the size of the soil particles.

Erosion, by wind or water, causes a lowered productivity of the land, a decrease in the value of farmlands and real estate, a decrease in the quality of products, and emigration of people from an area. It affects the water of an area by decreasing the amount of water "caught" and held by soil and, therefore, lowers the water table. Water will become polluted easier in areas of soil erosion, and the amount of sediment carried by the stream will be greatly increased.

All forms of erosion control are based on slowing down the velocity of the eroding agent. The water must be made to "walk off" the land rather than "run off". The slower the eroding agent travels, the less force it has. Man speeds up the erosion process primarily by removing the protective cover of the land. The most common practices that remove the vegetative cover are listed in the outline.

Throughout the history of man, the utilization and exploitation of soil has depended on climate, natural vegetation, and parent rock. For this reason, soil products vary from region to region, and different cultivated crops originated in different areas of the world.

In the Near East, Triticum and Hordeum are found wild and probably gave rise to early forms of Emmer wheat and barley respectively. These two grain crops occur together in practically all early archaeological sites in Mesopotamia and Egypt. Recent studies have demonstrated that high water flood periods in the Tigris-Euphrates Valley created extreme silting problems. The salt dissolved in the rivers was deposited in the soil and as time passed became concentrated. The history of this area shows that the people began evacuating the city around 1700 B.C. and moving to Babylon when the crop production started to decline. However, in less than 300 years, they suffered the same decrease in soil fertility that seems to coincide with the conquest by the Hittites.

In the climates of Mesoamerica, plants adapted to a different type of soil and were later domesticated and introduced throughout North America.

The evolution of the use of the soil appears to correspond with that of technology. Technology covers any act by which man handles, profits from, or modifies his physical or biological environment. As man progressed from a food-gathering stage through the stage of hunting and fishing to that of incipient food production, his technology advanced correspondingly. Man could not hunt animals until a tool for trapping or killing and butchering was developed. A different tool was required in order to clear fields, even though the actual planting may have been performed with the hands. More advanced forms of farming required the development of a more sophisticated assemblage of implements. Thus, digging sticks gave way to hoes, hand-pushed plows led to oxen-drawn plows, and in major cultural areas, various types of irrigation farming developed into full-scale control of soil and water supply. This should not imply that cultural evolution develops within a given population at a given rate. Instead, the development is one of a multi-linear nature with stages occurring in different groups at different times according to fluctuations in the physical and biological environments of those groups. Therefore, an entire cultural area may be considered as having evolved along the same general cultural lines; that is, Southeast Asia and the Near East evolved from different economic bases, but at the same general level of cultural complexity at slightly different time periods. Thus, soil and the way man uses it represents one segment of a complex mechanism that affects the evolution of man's culture.

It is no coincidence that Syria, Iraq, the Holy Land, parts of China, Mexico, and Greece--once seats of thriving civilizations--are now desert or semi-arid desert.

The unofficial closing of America's frontier is generally set at 1890 and thus ended nearly 400 years of continous movement in the search for new lands in America. Until this time, the pressure on the land was not great, for there were millions of acres of land and less than a million Indians. Today, this same land area supports a population which is already more than 200 million. Needless to say, the pressure on the land has increased enormously.

The immigrants found bountiful and productive soil in America. Productive soil plus the demanding struggle for frontier existence made them careless in their use of the soil. With the seemingly endless opportunities to move on to areas of better soil, it was easier to move than to attempt to maintain productivity of these first-tilled acres.

During the colonial period, tobacco and corn cultivation extracted a heavy price from the original soil. Thomas Jefferson, George Washington, and James Madison used scientific practices to stop or control soil erosion. However, land was so plentiful and cheap that not many paid attention to these efforts.

As the settlers moved westward, the process of unwise soil practices continued in many areas. In every section of the country in which soil depletion occurred, the accompanying social and economic problems became tremendously costly. "Soil-butchering" has left in its wake entire regions whose economic growth rate has been retarded or stopped. Nothing was done to alleviate the problem until 1938, when Dr. Hugh Bennett published a booklet, "Soil Erosion, a Natural Menace". However, the great dust storms of the thirties emphasized the erosion problem and started action against soil erosion with the formation of the Soil Erosion Service in 1933. In 1935, the name was changed to the Soil Conservation Service, a department that is active at the present time.

Local farm areas are organized into soil conservation districts financed by federal funds but controlled by the local group. Cooperative organization is used to plan and put into practice conservation practices suitable for the local area. The objective of this group is "the utilization of every acre within the limits of its capability and the protection of every acre in keeping with its need".

Additional basic land facts are:

1. Food comes largely from the soil.
2. Productive land around the world is of limited extent and is becoming more scarce and poorer wherever there is uncontrolled erosion.
3. Most of the people of the world are underfed. Hunger is a product of worn-out, unproductive land.
4. Hungry people make fertile ground for sowing the seed of discontent, strife, uprisings, and war.
5. Soil conservation is an inescapable part of national defense and a desirable standard of living.
6. Lasting conservation can neither be carried out nor maintained without the cooperation of landowners and operators.
7. Since nations have an unending interest in the land, governments should pay part of the cost of conservation.
8. We have approximately 500 million acres of good land left in the United States.

9. At what levels of population and income growth are strains likely to appear in today's pattern of land use?

More people, higher per capita incomes, increased leisure time, and greater mobility of population are creating varied demands for land resource development as recreational areas.

Land areas used to produce cash crops that are not surplus are in competition with urbanization.

Fifteen per cent of the United States population depends on waste disposal through dispersion in the soil. There are approximately 300,000 individual sewage disposal units installed each year requiring 75,000 acres of land.

10. Can the same land area that supported 180 million Americans in 1960 support 330 million in the year 2000 with the same high standard of living?

11. Growing population needs could be satisfied in the past by increasing acreage of cultivated land--nowadays we must increase productivity.

We have gone through a successful agricultural revolution since World War II. The average acre in 1960 yielded two-thirds more crops.

Since 1920, replacement of farm animals by machines has freed 80 million acres for crop production formerly used to produce horse and mule feed.

Reasons for increased production are: (1) shift of producing areas, such as cotton growing to California, (2) more acreage under irrigation, (3) more acreage per farm, (4) mechanization, and (5) plant breeding; selected breeding.

OUTLINE OF CONTENT MATERIAL

- I. Description
  - A. Many definitions (see page E-1).
  - B. It is a resource.
    - 1. Limited and complex.
    - 2. Renewable and indispensable.
    - 3. Can be improved over and above its original state.
    - 4. Subject to many pressures.
      - a. Urban housing developments.
      - b. Highway construction.
  - C. Profiles (layers).
    - 1. Topsoil or horizon A.
      - a. Uppermost layer.
      - b. Coarse mineral particles.
      - c. Partially decomposed organic matter.
      - d. Area of maximum biological activity.
      - e. Can support plant growth.
    - 2. Subsoil.
      - a. Horizon B.
        - 1. More compact.
        - 2. Smaller mineral particles.
        - 3. Less organic matter.
      - b. Horizon C.
        - 1. Parent material of the upper two layers.
        - 2. Very little soil life.
    - 3. Bedrock or horizon D.
      - a. Bottom layer.
      - b. Parent material of horizons A, B, and C.

- II. Components of the Soil
  - A. Solids.
    - 1. Inorganic.
      - a. Pebbles and clay from weathering processes.
      - b. Gives soil most of its weight and volume.
      - c. Supplies minerals needed for plant growth.
    - 2. Organic.
      - a. Living and dead plant and animal material.
      - b. Humus.
        - 1. Retains water.
        - 2. Releases minerals as it decays.
    - 3. Essential elements from the soil for plant growth.

    - a. Major elements.
        - 1. Nitrogen.
        - 2. Calcium.
        - 3. Phosphorus.
        - 4. Potassium.
        - 5. Magnesium.
        - 6. Sulfur.
    - b. Trace elements.
        - 1. Iron.
        - 2. Manganese.
        - 3. Boron.
        - 4. Copper.
        - 5. Zinc.
        - 6. Many others.

C. Liquids.
1. Dissolved salts caused by weathering.
2. Acid produced by bacterial decay of plant matter.
3. Water and dissolved gases of the atmosphere.
    - a. One of the raw materials for protoplasm.
    - b. A solvent - Minerals are dissolved permitting them to enter the roots of the plant.
4. Soil - water.
    - a. Hydroscopic.
    - b. Capillary.
    - c. Gravitational.

D. Gas.
1. Occupies pore spaces between solid particles.
2. Air furnishes the oxygen needed for respiration by:
    - a. Roots of plants.
    - b. Bacteria, fungi, nematodes, etc.
3. May have larger portion of carbon dioxide and water vapor than atmosphere; liberated by processes going on in the soil.

E. Soil must contain rock particles, humus, water, and air to support good plant cover.

F. Animal organisms of the soil.
1. Macro-animals.
    - a. Rodents.
    - b. Millipedes and centipedes.
    - c. Spiders.
    - d. Mites and ticks.
    - e. Snails.
    - f. Insects.
    - g. Worms.

    2. Micro-animals and protists.
        a. Nematodes.
        b. Protozoa.
        c. Others.
G. Plant and protist organisms of the soil.
    1. Roots of higher plants (legumes).
    2. Algae.
    3. Fungi.
    4. Actinomyces.
    5. Bacteria.
        a. Aerobic.
        b. Anaerobic.

III. Classification of Soils
A. Classification (three soil orders).
    1. Zonal order.
        a. Development.
        b. Characteristics.
    2. Intrazonal order.
        a. Development.
        b. Characteristics.
    3. Azonal order.
        a. Development.
        b. Characteristics.
B. Chart of classification of all soils (see chart at end of outline).
C. Texture of soil as determined by size of soil particles.
    1. Fine gravel (grains 1.0 - 2.0 mm in diameter).
    2. Sand.
        a. Coarse sand (grains 0.5 - 1.0 mm in diameter).
        b. Medium sand (grains 0.25 - 0.50 mm in diameter).
        c. Fine sand (grains 0.10 - 0.25 mm in diameter).
        d. Very fine sand (grains 0.05 - 0.10 mm in diameter).
    3. Silt (grains 0.005 - 0.05 mm in diameter).
    4. Clay (grains less than 0.005 mm in diameter).
D. Major textures of soil.
    1. Sandy soil.
        a. 80% or greater sand.
        b. 20% or greater silt or clay.
    2. Sandy loam.
        a. 20-50% silt and clay.
        b. Remainder sand.
    3. Loam.
        a. 20% or less clay.

        - b. 30-50% silt.
        - c. 30-50% sand.
        - d. Best type for most plant growth.
    - 4. Clay.
        - a. Greater than 30% clay.
        - b. 70% other materials.
- E. Types of soil (great soil groups).
    - 1. Podzolic soils.
        - a. Conditions needed for development.
        - b. Characteristics.
        - c. Major locations of this type of soil.
    - 2. Latosolic soils.
        - a. Conditions needed for development.
        - b. Characteristics.
        - c. Major locations of this type of soil.
    - 3. Chernozemic soils.
        - a. Conditions needed for development.
        - b. Characteristics.
        - c. Major locations of this type of soil.
    - 4. Tundra soils.
        - a. Conditions needed for development.
        - b. Characteristics.
        - c. Major locations of this type of soil.
    - 5. Desertic soils.
        - a. Conditions needed for development.
        - b. Characteristics.
        - c. Major locations of this type of soil.
    - 6. Local soil types.
        - a. Similar to major types.
        - b. Slight variations due to local climate, topography, etc.

IV. Structure of Soil
- A. Types.
    - 1. Blocky.
    - 2. Granular.
    - 3. Columnar and prismatic.
    - 4. Platy.
- B. Importance of structure.
    - 1. Affects rate at which water can be absorbed and transmitted downward.
    - 2. For most plants, granular or mixed granular and blocky is best.
    - 3. Maintenance of proper soil structure is as important as maintenance of plant nutrients.

- C. Soil constitution.
  - 1. Degree of compaction.
  - 2. Stickiness.
  - 3. Porosity.
  - 4. Consistency.

- V. Mineralogy of Soils
  - A. Coarse fractions of soils (gravel, sand, and silt).
    - 1. Act as individual particles.
    - 2. Are composed of rock fragments or primary minerals.
    - 3. Over short periods of time, they serve as relatively inert skeletons upon which more reactive constituents are assembled.
  - B. Fine fractions of soil (clay).
    - 1. Controls most of the important properties of a soil.
    - 2. Have the largest surface area.

- VI. Chemistry of Soils
  - A. Clays have the greatest influence on chemical activity of the soil.
    - 1. Most chemical reactions occur on the surface of soil particles.
    - 2. Clay particles are the smallest and most numerous.
      - a. Present largest surface area.
      - b. Have the most chemical activity.
  - B. Clay particles can hold various positive ions, such as: H^+, Na^+, Ca^{++}, and Mg^{++}.
    - 1. These can be replaced or exchanged.
      - a. Important in soil management and plant nutrition.
      - b. A change of ion concentration changes characteristics of the soil.
    - 2. The acidity or alkalinity of a soil depends on which of these ions predominate.
      - a. Acid.
        - 1. Predominately H^+.
        - 2. pH lower than 7.
      - b. Alkaline.
        - 1. Predominately Ca^+ or Na^+.
        - 2. pH higher than 7.
      - c. Neutral soil - pH of 7.

- VII. Formation of Soils
  - A. Factors influencing soil development.
    - 1. Climate.
      - a. Temperature and rainfall.
        - 1. Governs rate of weathering.
        - 2. Governs rate of decomposition of minerals.

   - b. Controls the kinds of plants and animals that can thrive in a region.
   - c. Broad soil regions of the world tend to be the same as the distribution of climates (not identical because of other determining factors in soil formation).

2. Parent rock.
   - a. Passive factor.
   - b. Must be weathered to produce soil.
   - c. Composition and structure influence rate and products of weathering.
3. Topography or relief.
   - a. Affects runoff.
   - b. Affects drainage.
     - 1. Steep slopes.
     - 2. Level slopes.
4. Biological activity.
   - a. Horizon differentiation of soil.
   - b. Results.
     - 1. Increase in organic matter in soil.
     - 2. Increase in nitrogen in soil.
     - 3. Gains or losses in plant nutrients in soil.
     - 4. Increase or decrease in porosity of the soil.
   - c. Plants.
     - 1. Lichens.
     - 2. Bacteria.
5. Time.
   - a. Long time for topsoil to develop.
   - b. Depends upon where and upon what the processes must act.
6. Modification of soil by man.
   - a. Soil testing to determine treatment.
     - 1. Obtaining a representative sample.
       - a. Selection of area to be sampled.
       - b. Depth of sampling.
       - c. Size of sampling.
       - d. Type of sampling.
     - 2. Soil testing procedures.
     - 3. Interpreting soil test.
     - 4. Utilization of soil tests.
   - b. Adjusting pH.
     - 1. Liming.
     - 2. Leaching of alkaline soil by irrigation.
     - 3. Others.
   - c. Addition of fertilizers.
     - 1. Fertilizer elements.
       - a. Nitrogen.

            - b. Phosphorus.
            - c. Potassium.
        - 2. Time of application.
        - 3. Quantity.
- B. Soil formation.
    - 1. Caused by the weathering process which consists of three simultaneous processes.
        - a. Physical disintegration.
            - 1. Abrupt temperature changes.
            - 2. Abrasion.
                - a. Glaciers.
                - b. Wind-blown sand.
                - c. Pebbles carried by water.
                - d. Others.
        - b. Chemical decomposition.
            - 1. Oxidation.
            - 2. Hydration.
            - 3. Corrosion by acids.
        - c. Addition of humus to the rock particles.
    - 2. Caused by biological activity.

VIII. Erosion
- A. Steps in soil deterioration.
    - 1. Biological deterioration.
        - a. A decrease in amount of organic matter.
        - b. Fewer burrowing animals.
        - c. Fewer plants (annuals rather than perennials).
    - 2. Physical deterioration.
        - a. Soil becomes more compact.
        - b. Smoother surface.
        - c. Fewer and smaller pores for water.
        - d. Granular structure of the soil begins to break down.
    - 3. Chemical deterioration.
        - a. Mineral deficiencies are present.
        - b. Considerable leaching has taken place.
        - c. Soil fertility has declined.
    - 4. Moisture deterioration.
        - a. Lowered water table.
        - b. Surface evaporation and runoff are high.
        - c. Percolation of water into soil is slow.
        - d. Drought injury is frequently evident.
    - 5. Erosional deterioration.
        - a. Water.
        - b. Wind.

B. Erosion.
  1. Definition.
  2. General facts.
    a. Beneficial as well as harmful.
      1. Slow, normal erosion exposes fresh minerals from underlying rocks at rates of 1 inch per 100 to 1,000 years.
      2. Accelerated erosion is harmful.
        a. Burning, grazing, forest cutting, or tillage.
        b. Most serious loss is change in structure of horizons and loss of topsoil.
    b. Cannot stop all erosion.
      1. Can control it.
        a. Protective cover of plants.
        b. Productive as well as protective.
        c. Utilizing conservation practices.
  3. Agents of erosion.
    a. Water.
      1. Raindrop splash.
        a. Puddle erosion.
        b. Fertility erosion.
        c. Sheet erosion.
      2. Flowing surface water.
        a. Carrying or moving power.
        b. Cutting or tearing power.
      3. Riparian and river channel erosion.
      4. Stages of water erosion.
        a. Sheet erosion.
        b. Rill erosion.
        c. Gully erosion.
      5. Freezing and thawing.
    b. Wind.
      1. How wind moves.
        a. Forward movement.
        b. Spinning movement - eddies.
        c. Puffing movement - gust.
        d. Swirling or tumbling movement.
      2. How wind moves the soil.
        a. Saltation.
        b. "Suspension movement".
        c. "Surface creep".
  4. Damage of erosion.
    a. Land.
      1. Lowered productivity of land in use.

        2. Decrease in value of farmlands and real estate.
        3. Decrease in the quality of products.
        4. Emigration of people.
        5. Dust storms.
        6. Decreases food for wild game.
    b. Water.
        1. Affects moving ground water.
        2. Easier for water to become polluted.
        3. Increase in amount of sediment carried and deposited.
        4. Lowers the water table.
        5. Increased floods taking toll of life and property.
5. The human factor in soil erosion.
    a. Man causes erosion.
        1. Removing native vegetation.
            a. Tree girdling.
            b. Commercial lumbering.
            c. Cultivation.
            d. Deforestation.
            e. Over-grazing.
            f. Fires.
            g. Lowering the water table.
            h. Strip mining.
            i. Building trails and roads.
        2. Allowing monetary gain to overrule sound ecological and conservation concepts.
    b. Man accelerates the erosion process.

IX. Control and Prevention of Erosion
    A. Education of the public.
    B. Conservation farming to reduce water erosion.
        1. Contouring.
        2. Terracing.
        3. Strip cropping.
        4. Crop rotation.
        5. Use of fertilizers.
        6. Irrigation.
        7. Sod waterways.
        8. Green manure.
        9. Woodlot management.
        10. Contour farming.
        11. Diversion channels.
        12. Mulching.
        13. Cover crops.

      14. Drainage.
      15. Pasture improvement.
      16. Gully control.
      17. Pond management.
      18. Reforestation.
      19. Use of soil maps.
      20. Check dams.
   C. Conservation practices to reduce wind erosion.
      1. Reduce wind velocity near the ground.
         a. Maintain crop growth.
         b. Erection of physical barriers.
      2. Increase soil aggregation.
      3. Decrease area of fields.
      4. Ridging.
      5. Terracing.
      6. Windbreaks (trees).

X. Historical Aspect of Soil
   A. Variation of plant forms caused by soil.
      1. The Near East.
         a. Natural and cultivated forms.
         b. Origin of wheat and barley.
         c. Influence on disintegration of Mesopotamia.
      2. Mesoamerica.
         a. Natural and cultivated forms.
         b. Origins of corn.
   B. Influence of soil types on development of corresponding technological forms.
      1. Evolution of technology and soil utilization.
      2. Influence of soil utilization on cultural evolution.
   C. Soil conservation in the United States.
      1. George Washington and Thomas Jefferson.
      2. Dr. Hugh Bennett.
      3. 1933: Congress created the Soil Erosion Service.
      4. 1935: It became the Soil Conservation Service.
         a. Soil conservation district.
            1. Conservation farm plan.
            2. Objective.
         b. Regional planning.
      5. Present soil conservation programs.

XI. Future Demands of the Land and Soil
   A. Land area of the United States consists of 2.25 billion acres.
      1. 450 million acres used for crop production.

2. 635 million acres used for non-forest grazing.
3. 750 million acres used for forests.
4. 65 million acres for urban, industrial, and transportational use.
5. 25 million acres for recreational use.
6. 325 million acres for all other uses.

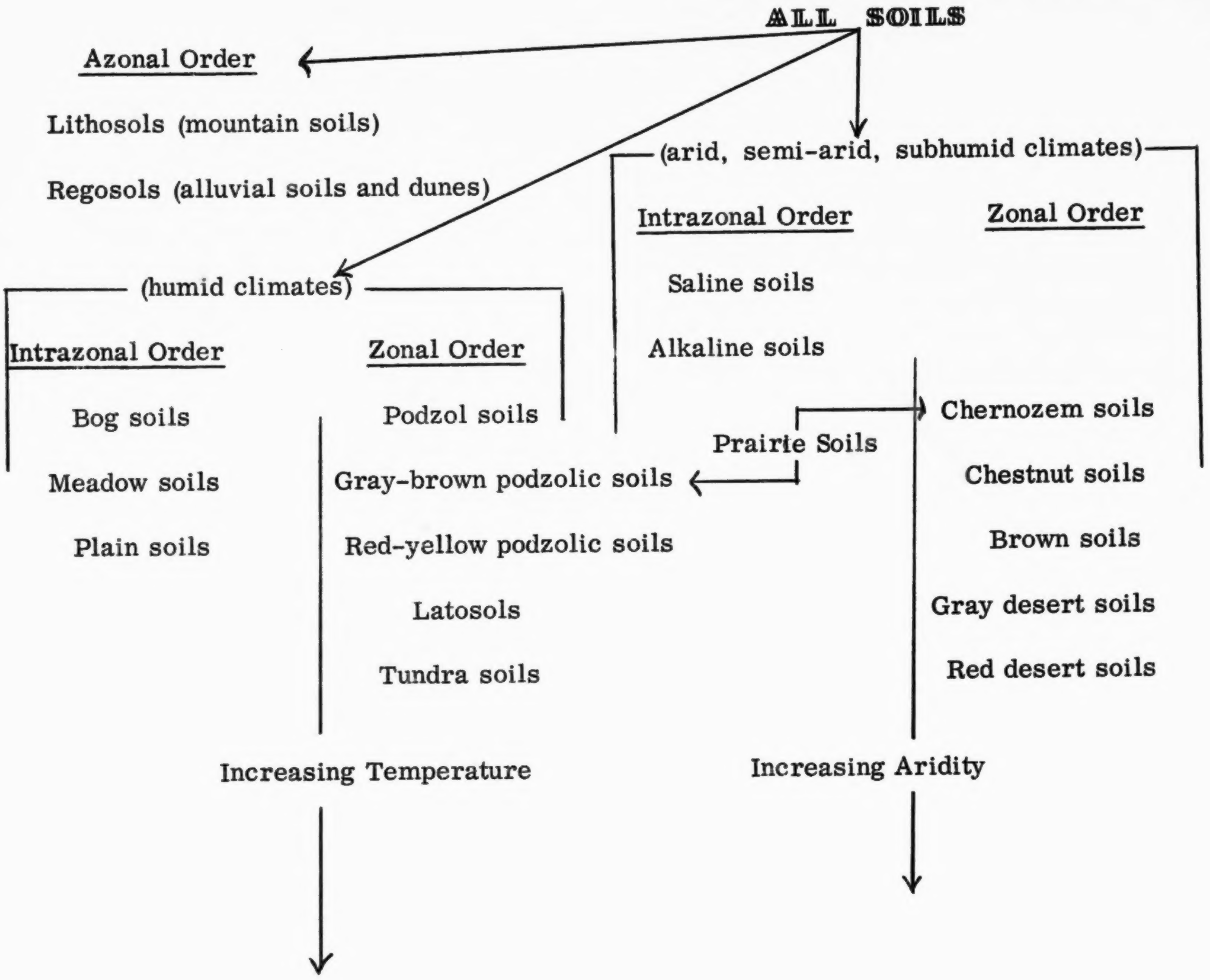
B. Nine out of ten acres of United States land are used for growing crops to be consumed directly, to be fed to livestock, or to be turned into fiber and forest products.

C. Eleven and one-half acres of land per person in the United States at the present time.
   1. Only three acres per person are used as crop lands.
      a. One-third is seriously eroded.
      b. One-third is moderately eroded.
      c. One-third is highly productive.
   2. Other eight acres.
      a. Recreation.
      b. Forest products.
      c. Urbanization.
      d. Wastelands.

D. Over the past fifty years, an estimated 400,000 acres of crop land per year has been lost to erosion.

SOIL CLASSIFICATION BY ORDERS & GROUPS

(From A. N. Strahler, The Earth Sciences, Harper and Row, p. 620, 1963)


ALL SOILS
Azonal Order
Lithosols (mountain soils)
Regosols (alluvial soils and dunes)
(arid, semi-arid, subhumid climates)
Intrazonal Order
Zonal Order
Saline soils
Alkaline soils
(humid climates)
Intrazonal Order
Zonal Order
Bog soils
Meadow soils
Plain soils
Podzol soils
Gray-brown podzolic soils
Red-yellow podzolic soils
Latosols
Tundra soils
Prairie Soils
Chernozem soils
Chestnut soils
Brown soils
Gray desert soils
Red desert soils
Increasing Temperature
Increasing Aridity

LEARNING ACITIVITIES AND MATERIALS

I. Learning Activities
   A. Demonstrations.
      1. Using a soil testing kit, test soil from different areas. Record and explain the differences. (Instructions are in the kit.)
      2. Obtain several flowerpots. Fill the first pot with poor soil (subsoil). Fill the second with subsoil and add some organic matter (humus). Fill the third pot with subsoil and add commercial fertilizer. Add organic matter and commercial fertilizer to the subsoil in the fourth pot. Fill the fifth pot with topsoil only. Plant several grain kernels in each pot. Give each pot equal care and attention. Note and explain differences between plant growth.
      3. Test a sample of soil for organic matter. Weigh the sample, dry it, and weigh it again to determine the water content. Now burn the soil and weigh it again to determine the weight of the organic material.
      4. Weathering processes:
         a. Rub two pieces of sandstone together.
         b. Heat a small piece of limestone and drop it quickly into a pan of ice water.
         c. Place some small pieces of limestone in vinegar. Heat the vinegar. The acid in the vinegar will react with the limestone and produce carbon dioxide bubbles. The limestone will eventually break down.
      5. Take three lamp chimneys or plastic cylinders and fasten thin cloth over the bottom of each cylinder. Fill one cylinder 3/4 full with sand, one with clay, and one with topsoil. (Make sure the soil is dry.) Invert the cylinders and place the cloth end of each under water. Note how long it takes for the water to move up the cylinders one inch, two inches, etc. This is capillary action. Compare the different soils.
      6. Line two funnels with clean filter paper and place in racks. Pour clear water into one of the funnels and muddy water into the other funnel. Explain how this action compares with that of puddle erosion.
      7. Demonstrate the effect of splash erosion by placing a small pile of sand out in the open. When it rains, the sand pile will be flattened. Place a coin or two at various spots on the sand pile.
      8. Collect samples of runoff water in jars from (a) a muddy stream, (b) a stabilized gully, and (c) a grassed waterway. Allow the sediment in each to settle. Determine the amount of soil carried in each gallon of water.
      9. Fill a pan with light soil. Mulch the soil with twigs or straw. Expose it to the wind from an electric fan for three minutes. Determine the amount of rippling or other soil movement. Remove the mulch. Expose the soil to the wind for one minute. Compare the results.

10. Try to remove the soil from a piece of dense sod by shaking it and then by running water over it to show how earth clings to the roots. Emphasize the importance of plant cover in preventing erosion.
11. Pour 1/2 inch of water into a quart jar. Fill the jar with light colored, dry sand. Observe the capillary action as the sand becomes moist.
12. Fill a quart jar 1/4 to 1/3 full with a mixture of fine clay, silt, sand, and fine gravel. Fill with water and vigorously shake the jar for a few moments and then place the jar on a table. After 24 hours, observe the sorting effect of water.
13. Collect leaf mold and soil from forest floors. Examine and note the breakdown in organic matter.
14. Acquire soil samples from different areas--woods, abandoned fields, good soil, etc. Note the different and similar plants, roots, and animals found in each sample.

B. Field trips.
   1. To find evidence of soil erosion, weathering, and leaching.
   2. To visit a farm where good conservation techniques are practiced. Note what is being done to control erosion (contour, strip farming, rotation of crops, diversion ditches, and check dams).
   3. To view soil profiles at an excavation site and note differences between topsoil and subsoil. Note differences between soil in forests, in pastures, in cultivated fields, and in gardens.
   4. To visit a farm to study gully erosion, sheet erosion, stream bank erosion, and wind erosion. (Write a paper describing how the various forms of erosion could be checked or prevented.)
   5. To an abandoned farm to determine why it was abandoned.
   6. To a rock quarry or a strip mine.
   7. To the Carnegie Museum (Pittsburgh) to see the exhibit, "Deadline for Wildlife".

C. Discussion.
   1. Discuss the effect of soil erosion on ancient civilizations.
   2. Discuss the responsibility of federal, state, and local government agencies in soil conservation.
   3. List basic commodities under food, clothing, and shelter to show how many of these are products of the soil.
   4. Discuss the time it takes natural forces to produce topsoil in relation to the amount of time it takes man to destroy it.
   5. Discuss the extent to which the local standard of living is dependent upon soil productivity.
   6. How does the character and quality of soil affect plant growth? Emphasize (1) plants most suitable for various kinds of soil and (2) the importance of soil quality in efficient production. How do these factors influence the cultures of different areas?

7. What factors are constantly changing the earth's surface (rain, wind, ice, snow, plants, animals, and man)?
8. Discuss factors which influence the rate of erosion.
9. Discuss the importance of crop rotation to soil fertility. (Be sure to include legumes.)
10. Comment on the following quotes:
    a. Jefferson - 1817: "Fields are no sooner cleared than washed."
    b. Patrick Henry - 1790: "He is the greatest patriot who stops the most gullies."
    c. Theodore Roosevelt: "When soil is gone, man must go."
11. What were the primary purposes of the early settlers and how did these purposes affect the early treatment of the soil? Of all the resources?
12. Discuss "What is soil?"
13. What would life be like if all of the topsoil would be lost?
14. Locate fertile and non-fertile areas in Pennsylvania. Discuss kinds of crops in different areas. Explain population movements in Pennsylvania during the last thirty years.
15. Discuss how soil usage has affected the history of peoples of other times and places.
    a. History of the Nile River Valley.
    b. History of Ancient Persia.
16. What is conservation farming?
17. How might you prevent soil erosion?
18. What is a lichen? Is it of any value?
19. What are the eight land capability classes?
20. What is the difference between a rock and a mineral?
21. Discuss the statement: "In a democracy, the use of the soil is the owner's right."
22. How can stopping erosion help to control floods?

D. Bulletin board displays.
1. Make pictures showing "before and after" erosion control practices of land.
2. Depict the ways in which good soil management can promote fish, wildlife, recreational, and industrial value of an area.
3. Show the minerals needed for plant growth.
4. To show the composition of commonly used fertilizers.
5. To show the agents of erosion and the types of erosion.
6. To show how to prevent erosion.
7. To show soil types found in the area.
8. To show the type of rocks found in the area.
9. To show the products that come from the soil.

E. Student activities and projects.
1. Make a model of a farm showing methods of controlling soil erosion.

2. Make a diagram to explain the movement of water in the soil and the movement of water up through the plants into the atmosphere.
3. Write a paper concerning the weathering processes and how they affect soil formation.
4. Write a paper presenting a 3-, 4-, and 5-year crop rotation plan and justify your choices.
5. Choose and briefly sketch a farm of your community and make recommendations as to its most desirable care and use.
6. Put a sample of damp soil and a leaf mixture into a small jar and label it with the date. Observe how long it takes for the leaves to mold, decay, and become part of the soil.
7. Look around the school grounds for erosion and mention ways it could be prevented or checked.
8. Collect and label soil samples from various areas.
9. Prepare a plan to prevent erosion on the school grounds.
10. Study the root system of an alfalfa plant, a grass plant, a dandelion, and a carrot.
11. Plant and care for a tree.
12. Prepare a plan to increase the amount of organic matter in the soil in your garden at home.
13. Prepare a list of things in your home that came directly or indirectly from the soil.
14. Write a paper on the origins of the soil conservation movement.

II. Learning Materials
   A. Audio-visual materials.
      1. See list of sources at the end of the guide.
   B. Books and pamphlets.
      1. Audubon Nature Encyclopedia, Vol. 10, p. 1867, copyright 1965 by National Audubon Society.
      2. Bennett, H. H., Elements of Soil Conservation, 2nd Edition, McGraw-Hill Book Company, 1955.
      3. Buckman, H. C. and Brady, N. C., The Nature and Properties of Soils, 6th Edition, The MacMillan Company, New York, 1960.
      4. Butler, M. D., Conserving Soil, D. Van Nostrand Company, Inc., Princeton, New Jersey, 1955.
      5. Clark, G., World Prehistory, Cambridge University Press, London, 1962.
      6. Coyle, D. C., "Conservation", Rutgers University Press, 1957.
      7. Dohrs, F., Sommers, L., and Petterson, D., Outside Readings in Geography, Crowell and Company, New York, 1955.
      8. Emde, George H., Soil Conservation and the Banker, New Brunswick, New Jersey, June, 1947.
      9. Helbaek, H., Paleobotany of the Near East and Europe in Braidwood, R. and

Howe, B., Prehistoric Investigations in Iraqi Kurdesian, Studies in Oriental Civilization, No. 31, University of Chicago Press, Chicago, 1960.

10. Honigmann, J., The World of Man, Harper and Row, New York, 1959.

11. Jacobson and Adams, R., Salt and Silt in Ancient Mesopotamia in Science, Vol. 128, No. 3334.

12. Kellog, C. E., "Soil", Scientific American, July, 1950.

13. Landsburg, H. H., Natural Resources for U. S. Growth, A Look Ahead to the Year 2000, Johns Hopkins Paperback, 1964.

14. Legget, R. F., Soil: Its Geology and Use, Bulletin of the Geological Society of America, Vol. 78, pp. 1433-1460, 1967.

15. Lyon, T. L. and Buckman, H. C., The Nature and Properties of Soils, The MacMillan Company, New York, 3rd Edition, 1957.

16. Marshall, C. E., The Physical Chemistry and Mineralogy of Soils, Vol. 1, Soil Materials, J. Wiley and Sons, New York, 1964.

17. McGraw-Hill Encyclopedia of Science and Technology, McGraw-Hill Book Company, New York, Vol. 12, "Soil", 1960.

18. Millar, C. E., Turn, L., and Futh, H. D., Fundamental of Soil Science, 4th Edition, J. Wiley and Sons, New York, 1965.

19. Nilsiforoff, C. C., Reappraisal of the Soil in Science, Vol. 129, No. 3343, pp. 186-189, January, 1959.

20. Research and Development on Natural Resources, a report prepared by the Committee on Natural Resources and the Federal Council for Science and Technology, May, 1963.

21. Robinson, G. W., Soils: Their Origin, Constitution, and Classification, 3rd Edition, J. Wiley and Sons, New York, 1959.

22. Soil, The 1957 Yearbook of Agriculture, U. S. Department of Agriculture, Washington, D. C.

23. "Early American Soil Conservationists", Miscellaneous publication #449, U. S. D. A., Soil Conservation Service, 1959.

24. Stallings, J. H., Soil: Use and Improvement, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1957.

25. Strahler, A. N., The Earth Sciences, Harper and Row, pp. 611-629, 1963.

26. Thornburg, W. D., Principles of Geomorphology, J. Wiley and Sons, New York, 1964.

WATER

BACKGROUND INFORMATION

Water is a covalent compound in which two hydrogen atoms and one oxygen atom share their electrons mutually. The shared electrons appear to spend more time near the oxygen nucleus than they do near the hydrogen nuclei. Thus, the oxygen part of the water molecule has a partial negative charge, and the hydrogen ends have a partial positive charge. The positive ends of water molecules attach themselves to the negative end of other water molecules forming a hydrogen bond. Hydrogen bonds are very difficult to break. This explains many of the properties of water.

It is a very stable compound that occurs in the three states of matter (solid, liquid, and gas). Most substances contract when cooled, but water possesses the unusual behavior of expanding when freezing. Ice has a lower density than does liquid water. Water has its greatest density at 4° C. This is an important factor to organisms that live in the water. If water did not expand as it freezes, ponds would freeze from the bottom up; and this would prove disastrous to water organisms.

As discussed in the energy unit, any type of change is accompanied by energy transfer. For ice at 0° C. to change to water, without an increase in temperature, requires eighty calories per gram. This is called the heat of fusion. Heat of vaporization refers to the amount of heat required to change one gram of water at 100° C. to steam at 100° C. This requires 540 calories per gram of water.

Water is important to life both as a building material and as a dissolving substance. A material that is capable of dissolving another material is called a solvent while the material being dissolved is a solute. Although water cannot dissolve everything due to its polar structure, it is capable of dissolving a large variety of materials and is referred to as the "universal" solvent. Protoplasm, the "living material", is approximately 75% water, and blood is approximately 60% water. Inside the organism, water is used as a lubricant, a transporter of food and wastes to various organs, and as a medium in which many of the chemical reactions take place.

Water serves as a cooling agent. As a higher vertebrate perspires or a plant transpires, it is cooled because the liquid water must absorb heat to change to a gas. This heat of vaporization is taken from the plant or animal and, therefore, acts as a cooling device for the organism.

The distribution of water (usable and fresh) is extremely uneven owing to differences in climate, surface, and subsurface storage conditions. Settlement patterns around the world reflect this distribution. For example, Egypt's population is quite disproportionate in its distribution due to the importance of the Nile River and the economic influence it exerts.

The history of irrigation and terracing is closely related to the development of an elaborate social system and important urban centers. Dense populations cannot be maintained without some form of irrigation, be it merely periodic flooding (Egypt), canals cut from large rivers (Mesopotamia), lock systems (China), or intricate canals forming dendritic patterns bringing water to many small villages and hamlets.

In Mesoamerica where arable land was at a premium, some of the early inhabitants constructed "chinampas" or floating grain fields about one square acre in size and eighteen inches deep made of soil, mud, straw, and hay. The "chinampas" were placed in a lake where they floated and absorbed water. The field was then cultivated in the usual manner.

The Dynasties of Ancient China were economically based on a massive work force and irrigation of riverine basins. The land was owned by the peasants, but the water and irrigation mechanisms were owned by the emperor and his ministers. Control of the water supply meant control of the economy, and even life.

In Queensland, Australia, water is valuable and hard to find. In response to this the Arunta (Australian aboriginae) are physiologically acclimatized to low water requirements. Strong warriors have been known to go for days without having enough water for more than wetting the lips. Similar in climate and water scarcity, Saudi Arabia and her people have adapted to different ways. The R'walla travel at night to conserve water. Horses, although high status symbols, require too much water; consequently, camels are used for long trips and as beasts of burden. Water is so valued that anyone stealing water is put to death. In Botswana the !Kung bushmen of the Kalihari Desert must search constantly for water. Hence, when an animal is killed, the body fluids are consumed first and function as a water substitute.

The tropical rain forest, home of the Mbuti pygmy tribe, is a principle area of fresh water in the world. There is plenty of precipitation in the forests, but the evaporation rate is so great that most fresh water is lost in a very short period of time. The Mbuti must search for holes and pockets in trees that trap and hold the water. The other source of water is to drink the fluid from the liana plant.

The seal, or Netsilingmiut Eskimo, have an excess supply of water in the form of ice and snow. Ice is used to construct houses. Melted snow and mint are boiled for a form of tea. The importance of snow to the Eskimos is seen in the fact that their language contains fourteen different words for snow.

The Siriond Indians of Columbia, a nomadic group of hunters, are adapted to water of extreme pollution and apparently do not suffer from the various protozoan infections which cause diseases in urban populations.

At present the bulk of the water we use comes from precipitation. If evenly distributed over the surface of the United States, the average annual precipitation would be thirty inches.

Approximately 40% of our people live in cities of 100,000 or more. The great majority of these cities use surface water obtained from lakes, streams, or reservoirs. Unfortunately, surface water is usually polluted and must be treated accordingly.

About 30% of the people live in cities of less than 100,000. Many of these cities use surface water; but in the Mississippi Valley, the West, and the Southwest, ground water from deep wells is used whenever available.

The other 30% of our people live in small communities and rural areas. Ground water from deep wells is the common source of water. In a few favored areas such as: Florida, Oregon, northern California, southern Idaho, and Missouri, artesian wells may supply an abundance of fresh water.

Juvenile water is that water derived from igneous activity within the earth. This, plus the water formed in connection with the formation of the earth and its atmosphere, constitute the original supply of water. This same water is used many times as will be explained in the hydrologic cycle.

The idea that forests create water and more water can be formed by reforestation is a misconception referred to as "forest water". It is true that forests will trap and hold water, but they cannot create water. Primary water refers to the idea that there is a "new" non-hydrologic source of water. (This is also a misconception as it is really juvenile water.)

The major source of our fresh water is the ocean. It may seem strange that the salt water from the ocean is our source of fresh water. This change is brought about by a cycle of events called the hydrologic cycle. Evaporation takes place over the ocean which causes the liquid water to change to the gaseous state. The saline content in different salt-water bodies around the world varies directly with the rate of evaporation for each area; for example, in the Dead Sea salinity concentration is over 1500 parts per thousand, but in the Arctic Ocean it is only 10-15 parts per thousand. However, the temperature is not high enough to cause the salts to change to a gaseous state, and they remain in the ocean. As the air currents move inland, the air is cooled either by mixing with cooler air masses or by gaining altitude. The amount of moisture that the air can hold in a gaseous state is in direct proportion to its temperature. As the temperature decreases, the ability of the air to hold water decreases also.

Relative humidity is a term used to designate the amount of moisture in the air compared to the amount it could hold at a given temperature. As the temperature of the air drops, with the amount of water vapor remaining constant, the relative humidity increases until it equals 100%. At this point, the air is saturated and the dew point is said to have been reached. Any reduction of temperature below the dew point causes the air to have more water than it can hold, and the water vapor will condense and form liquid water droplets in the form of clouds. If this process continues, the droplets become too heavy to remain in the air, and some form of precipitation occurs. Rain occurs when the dew point is reached above 32° F., and snow is formed when the dew point is reached below 32° F. Sleet occurs when rain is formed in the atmosphere but passes through a layer of air with a temperature below 32° F. as it falls to the earth. Very turbulent air conditions consisting of warm and cold layers of air result in the formation of hail.

On calm nights when the layer of air next to the earth is warmer than the surface of the earth itself, either frost or dew is formed. The only difference between the two is the temperature at which the dew point is reached. Below 32° F., frost is formed; and above 32° F., dew is formed. In both cases, the moisture from the air condenses directly on the surface of the earth.

The hydrologic cycle consists of liquid water changing to gaseous water and moving into the atmosphere by evaporation or transpiration where it is condensed and falls to the earth in some form of precipitation.

If the precipitation drains directly off the mountain into a stream and on to the ocean, we call it "runoff". This is the surface water used and reused by so many of our cities as it returns to the ocean. If the raindrop re-evaporates directly from the mountain top or from the surface of the stream on the return to the ocean, we call it "fly-off". Such water is temporarily lost to us; but in time, it again returns to us as rain or snow. If the raindrop seeps into the ground, it becomes a part of the ground water. That ground water which is in the upper layer of the soil may be absorbed by the roots of plants, part of which is then used for life processes (including transpiration). If the ground water seeps deeper into the earth, it soon reaches the zone of saturation, the upper surface of which is known as the water table. From this zone of saturation, water may seep to the surface to form springs or may remain in porous underground rocks until pumped to the surface by man.

The characteristics and methods of improving a watershed are listed in the water outline. The major objective of any watershed management program is to "hold" as much of the precipitation as possible and to reduce the rate and amount of runoff and fly-off.

It has been estimated that in the United States we use twenty-five gallons of water per person per day for primary domestic use. Secondary domestic uses probably vary from thirty gallons per person per day in communities of less than 500 to one hundred gallons per person per day in cities of 25,000 or over. As the size of the city increases, so does the per capita consumption of water. Billions of gallons of water are used per year for agricultural uses. However, unlike other uses, this water is usually returned to the hydrological cycle in as good, if not better, condition than it was received. The estimate of water usage for industrial purposes is 160,000 gallons per person per year.

Since the beginning of time, running water has been the easiest and cheapest method of disposing of waste products. Within limits, running water containing waste materials, if exposed to sunlight and air, will purify itself. However, with the recent industrial expansion, population explosion, and urbanization, many abuses have arisen from this practice when excessive amounts of waste products have been dumped into nearby streams.

Water was and is one of the cheapest methods of transportation, but it is also one of the slowest. Coastal and inland communities have long used the sea and rivers as highways connecting many communities and cultures. Man has constructed and used a great variety of ships to transport his goods, foods, and military power from country to country. Water, as a means of transportation, has definitely affected the history and culture of the people of the world. For example, the Phoenicians sailed little pilot boats on the Mediterranean as they pursued their trading business which resulted in the diffusion of the first coinage. Ships allowed Spain and England to discover new lands and to build empires reaching around the world. Consider also the Vikings of Sweden and their complete dependence on the ocean for a livelihood.

At the present time, only 4% of the energy requirements of our nation comes from water power. (Oil, coal, and natural gas furnish 96%.) Such a use of water is a non-consumptive use in that the water is returned to the stream unaltered and is immediately ready for reuse. One exception to this, in some cases, is thermal pollution. More recently, man has seriously considered harnessing the tides as a source of energy. This is one of the most extensive but least used sources of energy that we have. Normally, the difference between high and low tide is three feet of water, but there is considerable variation. In areas where there are funnel-shaped estuaries, the difference between high and low tide may be as much as sixty feet, as in the Bay of Fundy. It might be profitable to build a dam with gates that could be opened as the tide is coming in and then closed when the tide reaches its peak. As the tide recedes, the water behind the dam could be used to generate hydroelectric power as it is released to the ocean again. The Rance Estuary in France and several areas in Maine and New Brunswick have been considered for this purpose.

The face of the earth is constantly changing, and the most important single factor in this change is water. Water that seeps into rock cracks by day may be frozen at night and enlarge the cracks thus breaking the rock into smaller pieces. During past geologic ages, water in the form of continental glaciers has pulverized rocks and carried them many miles from their origin. The waves of the ocean are constantly bombarding and changing the shape of shorelines. Water also dissolves material from the soil and rocks it passes over. This material is sorted and deposited in inland seas and the oceans to become the parent rock for future soil millions of years in the future.

The major water problem in the United States is not quantity, but quality and availability. We receive an average of thirty inches of precipitation each year. However, this water does not always fall where and when we need it. The problem then is to be able to store this water so that it is available as needed. An adequate supply of water is influenced by the seasonal and regional distribution of rainfall. The outline lists areas of the United States and the annual precipitation yield. Those areas near large bodies of water generally receive more precipitation than inland areas. However, the topography, the amount and type of vegetation, the type of soil, and the way the land is used determine the quantity and length of time the water will be retained in the soil.

Precipitation falling on an area where the land is used according to its ability and where good management practices are used will be slowed down to the extent that a large portion of the water will soak into the ground and become part of the ground water. Runoff will be held to a minimum and conservation of water for a future date will be at a maximum. Areas such as this do not usually suffer from droughts or floods.

Barren ground, devoid of vegetation due to over cultivation, poor farm practices, and deforestation, offers little help in holding water. Most precipitation striking this type of land immediately becomes runoff and fills streams with an abundance of water, sediment, and silt and causes floods. The inability to hold water lowers the water table and makes the ground even more unfit to support vegetation. This is a vicious cycle that gets worse and worse. Therefore, the best way to prevent floods, droughts, and erosion is to use good land management before any of these conditions exist.

Pollution may be defined as the defilement or contamination of any water in such a way as to make it unfit for consumption, industrial use, supporting life, or aiding recreation.

Water pollution is a hazard to our health, a threat to our recreational facilities and economic growth, and a disgrace to the American people. Today, many factors in our society are conspiring to increase the amounts and perils of the wastes we dump into our water--our growing population, our new industrial techniques and products, and our new methods of agriculture. Yet these same forces are also increasing our need for dependable supplies of clean water.

Industrial wastes and municipal wastes pollute streams by dumping untreated or improperly treated wastes into the water supply. Flooding causes pollution by removing soil from the land and carrying it along until it settles to the bottom as silt and sediment. Water draining through open mines increases the acidity of streams above the life tolerance level and aquatic organisms die. Ships and boats contribute to water pollution with oil slicks and by dropping refuse overboard. The large oil tankers present a problem by breaking apart in heavy seas and expelling the oil into the water. The oil pollutes the water and beaches and causes a problem for the wildlife in the area. Many times, the detergents used to disperse the oil do more damage to the ecology of the area than the oil. Spraying fields with pesticides helps pollute the ground water. Modern day detergents are next to impossible to remove from the water and remain as a form of pollution.

The greatest damage to our streams comes from the chemical reactions that occur in the mines. Pyrite (fool's gold) combines with oxygen to form sulfur dioxide and ferrous sulfate. Water running through the mine forms sulfuric acid with the ferrous sulfate and oxygen. The ferrous sulfate and sulfuric acid then combine to form ferric sulfate. Ferric sulfate is the yellow precipate that forms the yellow covering in polluted streams.

The best way to prevent stream pollution from mine drainage is to prevent oxygen and water from coming in contact with pyrite. This can be accomplished by back-filling mines, especially strip mines. If the oxygen is kept away from the pyrite, the first step cannot occur; consequently, stream pollution by mines will be reduced or eliminated (see unit on minerals).

Most of the causes and cures of water pollution are known to science. The major problems are to educate the public to the dangers of water pollution and how they contribute to it and then to persuade the public to spend money to cure pollution.

Purification of water for use or reuse, as is usually the case, consists of several steps; each of which may be done in various ways or in combination with others. The first step is usually removal of suspended impurities. This can be accomplished by:

1. Filtration: Removal of suspended particles by passing the water through a porous material.

2. Sedimentation: The suspended particles are removed by settling under the influence of gravity.

3. Coagulation: The suspended particles are caused to clump together by a coagulating agent (alum) and then removed by settling.

After the larger particles are removed, bacteria must be removed or destroyed. Boiling, ultraviolet light, chemical treatment, freezing, and aeration are methods that will kill the bacteria. Removal of non-volatile impurities can be accomplished by vaporizing the water and then condensing it again. Changing salt water to fresh water may be a future source of fresh water. This can be accomplished by the methods listed in the outline. At the present time, the known methods for converting sea to fresh water are too expensive or too slow to be economically feasible. Water can also be modified by fluoridation, a process where soluble fluoride is added to the water to help prevent tooth decay. There is considerable controversy in many cities concerning this process.

A good sewage treatment plant consists of primary and secondary treatment. The general operation includes passing the sewage through a communitor where it is ground up. Next it undergoes temporary storage in an aerobic digester where bacteria start to decompose the waste. From the digester it passes to a settling basin where the solid particles (sludge) collect on the bottom. The liquid from the settling basin is filtered and chlorinated before being dumped into a stream. The sludge is then dried, heated to kill the bacteria, and then sold as fertilizer.

The problem is not that we do not have enough water, but that precipitation is not spaced evenly over the United States. Therefore, we must learn to protect our water supply in such a way that the water is fit for reuse. Our watersheds and lands must be managed and maintained so that the water will remain where it falls and be stored for further use.

OUTLINE OF CONTENT MATERIAL

I. Properties of Water
  A. Composition.
    1. Two parts hydrogen to one part oxygen by volume.
    2. Eight parts oxygen to one part hydrogen by weight.
  B. Physical.
    1. Boiling point (normal atmospheric pressure).
      a. 212° F.
      b. 100° C.
    2. Freezing point.
      a. 32° F.
      b. 0° C.
    3. Density - 62.4 pounds per cubic foot; one gram per cubic centimeter (at 40° C.).
    4. Exists in all three states: solid, liquid, and gas.
    5. Odorless, colorless, and tasteless if pure.
      a. "Pure" water is practically non-existent in nature.
      b. Tap water is not pure.
  C. Chemical.
    1. Stability of water.
    2. Reaction with active metals.
    3. Reaction with metallic oxides.
    4. Reaction with non-metallic oxides.
    5. Water of hydration.
  D. Structure.
    1. Polar molecule.
    2. Hydrogen bonding.
  E. Water and heat.
    1. Specific heat.
    2. Physical forms of water.
      a. Ice.
        1. Heat of fusion.
        2. Abnormal behavior of water upon freezing.
      b. Liquid water.
      c. Water vapor (steam).
        1. Heat of vaporization.
  F. Other properties.
    1. Vital part of and necessary for life--both plant and animal.
    2. Capillarity.
  G. Water solution.
    1. Components of solutions.

a. Solute.
  1. Solids,
  2. Liquids.
  3. Gases.

b. Solvent.
  1. Water - nearest approach to a "universal" solvent.

2. Concentrations of solutions.
  a. Dilute.
  b. Concentrated.
  c. Percentage concentration.
  d. Molar.
  e. Normal.

3. Properties of solutions.
  a. Freezing point depression.
  b. Boiling point elevation.

II. Need for Water

A. Water is essential to life.
  1. Protoplasm - chiefly water.
  2. Used as a lubricant in tissues.
  3. Used to remove waste materials.
    a. Kidneys.
    b. Sweat glands.
  4. Used to transport materials from one part of the organism to another (blood: 60% water).
    a. Oxygen from the lungs to the cells of the body.
    b. Carbon dioxide from the cells to the lungs.
    c. Food from small intestine to the cells.
    d. Minerals from the roots of plants to the leaves, stems, fruit, etc.
    e. Food from the leaves to other parts of the plant.
  5. Used to regulate body temperatures.
    a. Perspiration has a cooling effect.
    b. Transpiration has a cooling effect.
  6. Photosynthesis.

B. Affects temperature of surroundings due to its insulating effect.
  1. Near a large body of water.
    a. Temperature cooler in summer.
    b. Temperature warmer in winter.
  2. Air with high relative humidity varies less in temperature than air with low relative humidity.
    a. Desert temperature may vary from 120° F. during the day to 20° F. at night.
    b. In humid forest areas, daily difference in temperature between day

and night seldom exceeds 30° F.

- C. Civilizations.
  - 1. Ancient.
    - a. Mesoamerica.
    - b. Ancient China.
  - 2. Modern.
    - a. Australia.
    - b. Saudi Arabia.
    - c. Congo.
    - d. Eskimos.
    - e. Columbia.
    - f. United States.

- III. Water Supply
  - A. Private water supplies.
    - 1. Wells, springs, and cisterns.
    - 2. Small reservoirs and farm ponds.
    - 3. Private water companies or captive companies owned by industry.
    - 4. Aquifiers.
  - B. Public or municipal water supplies.
    - 1. Most Americans secure their water from public water supplies.
      - a. 40% of our people live in cities of 100,000 or over.
      - b. 30% of our people live in cities of less than 100,000.
        - 1. a. and b. use primarily runoff water.
        - 2. Must be treated.
      - c. Other 30% of our people live in small communities and rural areas.
        - 1. Ground water major source of water.
        - 2. Wells and springs.
  - C. World's supply estimated at 326,003,100 cubic miles.
    - 1. 324,000,000 cubic miles in lakes, rivers, oceans, and glaciers.
    - 2. 2,000,000 cubic miles in the soil and rocks.
    - 3. 3,100 cubic miles in the atmosphere.
  - D. Methods of improving and insuring supply.
    - 1. Recycling cooling water for industry.
    - 2. Reclaiming and reuse of process water.
    - 3. Use of sewage effluent.
    - 4. Better treatment of water.
    - 5. Use of sea water for coastal cities.
      Example: Plant in Freeport, Texas.
    - 6. Metering.
    - 7. Transporting water great distances underground to prevent evaporation.
    - 8. Improving storage facilities.
    - 9. Better control of the use of ground water.

IV. Requirements for Good Water
  A. Must not contain disease-causing bacteria, e.g. typhoid, cholera, and dysentery.
  B. Must be free of odor.
  C. Must be free from too many minerals, such as: salt, sulphur, and iron.
  D. Must be clear.
  E. Must be safe and suitable for desired use.

V. Sources of Water
  A. Juvenile water.
  B. Forest water (not substantiated).
  C. Hydrologic cycle.
    1. Precipitation.
      a. Types of precipitation.
        1. Rain.
          a. Formation.
          b. Rainmaking.
            1. Dry ice (CO_2).
            2. Silver iodide.
        2. Snow (10" of snow = 1" of rainfall).
        3. Dew and frost.
        4. Sleet.
        5. Hail.
      b. Characteristics of precipitation.
        1. Form.
        2. Depth - usually expressed in the equivalent of inches of water.
        3. Intensity - expressed in terms of the amount in a given period of time.
        4. Duration - the period of time during which precipitation continues at any given intensity.
        5. Impact force - the force with which it strikes the ground.
        6. Frequency - used to express the number of times storms may be expected in a given locality.
          a. Drought.
          b. Floods.
      c. Actions of precipitation.
        1. Runoff.
        2. Fly-off.
        3. Infiltrate - percolate.
        4. Determining factors of above actions.
          a. Rate and form of precipitation.
          b. Type and density of vegetation.
          c. Season of year.

            - d. Air temperature and humidity.
            - e. Soil type.
            - f. Land surface characteristics.
            - g. Configuration of bedrock.
        - 2. Evaporation and transpiration.
    - D. Ground water.
        - 1. Water table.
            - a. Zone of saturation.
            - b. Depth of table.
                - 1. Thickness of rock.
                - 2. Vegetation and cover.
            - c. Wells and springs.
                - 1. Ordinary well.
                - 2. Artesian.
                - 3. Mineral springs.
                - 4. Hot springs.
                - 5. Hillside spring.
    - E. Runoff water.
        - 1. Permanent streams.
        - 2. Intermittent streams.
        - 3. Lakes.
            - a. Natural.
            - b. Man-made.
            - c. Fresh-water.
            - d. Salt-water.
        - 4. Swamps and marshes.
        - 5. Oceans.

- VI. Watershed.
    - A. Drainage area.
    - B. Characteristics of a healthy watershed.
        - 1. Abundant plant growth.
        - 2. Porous soil containing:
            - a. Abundant humus.
            - b. Millions of bacteria and fungi.
            - c. Numerous burrowing animals.
        - 3. High, non-fluctuating water table.
        - 4. A minimum of erosion.
    - C. Watershed management.
        - 1. Multiple land use.
        - 2. Experimental management.
        - 3. Laws.
            - a. Riparian rights.

        - b. Priority rights.
        - c. Equal distribution.
  - D. Watershed improvement.
    - 1. Reforestation.
    - 2. Conservation farming.
    - 3. Fire control.
    - 4. Flood control.
    - 5. Control of mining operations (strip).
    - 6. Prevention of overgrazing.
    - 7. A minimum of large-scale road construction.

- VII. Use of Water
  - A. Domestic use.
    - 1. Primary domestic uses.
      Examples: Drinking, cooking, baths.
    - 2. Secondary domestic uses.
      Examples: Sewage disposal, watering lawns, washing cars.
  - B. Agricultural use.
    - 1. Irrigation and watering stock.
      Example: Estimated that 400 pounds of water to produce 1 pound of wheat and 10 tons of water to produce the grass required to produce 1 pound of beef.
  - C. Industrial use.
    - 1. As a raw material.
    - 2. For cooling purposes.
    - 3. For disposal of waste products.
  - D. Sewage and waste disposal.
  - E. Transportation.
    - 1. Slow but one of the cheapest methods.
    - 2. Natural and man-made waterways.
  - F. Water power.
    - 1. Primarily for production of electricity (a non-consumptive use).
    - 2. Tides for electricity.
  - G. Recreation.
    - 1. Swimming.
    - 2. Surfing.
    - 3. Fishing.
    - 4. Boating.
    - 5. Water skiing.
  - H. Various wildlife habitats.
    - 1. Swamps.
    - 2. Marshes.
    - 3. Bogs.

        4. Rivers and streams.
    I. Solvent systems.
    J. Standard of comparison for physical properties.

VIII. Expenditure of Water
    A. Present time in the United States.
        1. About 1,800 gallons/person/day.
            a. About 1,700 gallons are used for irrigation and industry.
            b. 100 gallons per day for personal use.
    B. Present time in underdeveloped countries.
        1. About 10 gallons/person/day.
        2. Will increase as technology increases.
    C. Most of this use of water is non-consumptive.
        1. Returned to water cycle.
            a. Pollution - not use is the problem.

IX. Environmental Changes Due to Water
    A. Major agent in breaking down rocks to form soils.
        1. Freezing and thawing.
        2. Chemical combinations.
    B. Glaciers.
        1. Alpine.
        2. Continental ice sheets.
            a. Stationary.
            b. Retreating.
            c. Advancing.
    C. Waves.
        1. Form shorelines.
        2. Change shorelines.
    D. Running water.
        1. Erosion.
        2. Youthful, mature, and old-age streams and landscapes.
    E. Materials dissolved in water.
        1. Sorts material according to size and weight.
        2. Deposits material in inland lakes.

X. Water Problems
    A. Adequate supply influenced by:
        1. Amount of rainfall (rainfall over geographic areas of the United States):
            a. Missouri type: 20-30 inches.
            b. Ohio type: 35-40 inches.
            c. New England type: 40-50 inches.
            d. Atlantic type: 45-55 inches.

        - e. Florida type: 50-55 inches.
        - f. Northern Gulf Coast type: 35-60 inches.
        - g. Texas Coast type: 25-45 inches.
        - h. Missouri Plateau type: 10-20 inches.
        - i. Northern Plateau type: 10-20 inches.
        - j. Southern Plateau type: 10-15 inches.
        - k. Northern Pacific type: 40-50 inches.
        - l. Southern Pacific type: 10-15 inches.
    - 2. Seasonal distribution of rainfall.
    - 3. Amount of vegetation.
    - 4. Type of soil.
    - 5. Land topography.
    - 6. Land use.
    - 7. Nearness to the ocean.
- B. Quality of water for usage.
    - 1. Odor.
    - 2. Mineral content.
    - 3. Temperature.
    - 4. Turbidity.
    - 5. Safety (bacterial content).
- C. Flooding.
    - 1. Best control is prevention.
        - a. Prevent excessive runoff by reforestation and conservation farming.
        - b. Dams, retarding basins, dredging of rivers, levees, and flood plain zoning.
    - 2. Causes of flooding.
        - a. Rapid runoff.
        - b. Precipitation and temperature.
        - c. Poor channeling of rivers.
        - d. Topography of the land.
        - e. Poor soil maintenance and erosion.
        - f. Inadequate dams, locks, flood walls, and flood gates.
- D. Lowering of the water table.
    - 1. Process.
    - 2. Prevention.
        - a. Wise land use.
        - b. Good watershed management.
- E. Erosion.
    - 1. Sheet.
    - 2. Gully.
    - 3. Riparian.

XI. Pollution

- A. Causes.
  - 1. Industrial wastes.
  - 2. Municipal wastes.
    - a. Domestic sewage.
    - b. Discharge from storm sewers.
    - c. Solid refuse from garbage.
  - 3. Sewage.
  - 4. Bacteria.
    - a. Natural water bacteria.
    - b. Soil bacteria.
    - c. Intestinal bacteria.
    - d. Microscopic organisms.
  - 5. Silt and debris.
  - 6. Detergent contamination.
  - 7. Oil slicks.
  - 8. Sediment.
    - a. Clay and silt.
    - b. Organic matter.
  - 9. Mine seepage.
    - a. Acid mine water drainage from unsealed mines or open-pit mining operations.
    - b. Reactions.
      - 1. In the mine.
        - a. Pyrite + oxygen yields.
          - 1. Sulfur dioxide.
          - 2. Ferrous sulfate.
        - b. Water + ferrous sulfate yields sulfuric acid.
      - 2. In the stream.
        - a. Ferrous sulfate + sulfuric acid yields ferric sulfate.
        - b. Ferric sulfate + water yields sulfuric acid.
  - 10. Salt-water enroachment.
  - 11. Thermal pollution.
  - 12. Insecticides and herbicides.
- B. Consequences of water pollution.
  - 1. Diminishes "good" water supply.
  - 2. Damage to metal structures.
  - 3. Damage to wildlife.
  - 4. Loss of recreational value.
  - 5. Decrease in property value.
  - 6. Disease.
- C. Correction of pollution problem.
  - 1. Education.

2. Pennsylvania laws.
    a. 1761: Mine drainage.
    b. 1945: First strip-mine law passed to regulate back-filling.
    c. 1947: Sanitary Water Board formed.
    d. 1961: Strip-mining law (back-filling).
3. Good watershed management.
4. Sewage treatment plants.
    a. Comminutor.
    b. Temporary storage in an aerobic digester.
    c. Transfer to a settling basin.
    d. Liquid is filtered and chlorinated.
    e. Sludge is dried, heated, and sold as fertilizer.
    f. This method does not remove detergents.
5. Seal abandoned mines and back-fill all strip mines.
    a. Prevent oxygen from coming into contact with pyrite.
    b. Prevent water from coming into contact with pyrite.
6. Research programs.
    Example: Penn State Sewage Treatment.

XII. Purification
- A. Removing suspended impurities.
    1. Filtration.
    2. Sedimentation.
    3. Coagulation.
- B. Killing bacteria.
    1. Boiling.
    2. Ultraviolet light.
    3. Chemical treatment.
        a. Chlorination.
        b. Coppering.
    4. Freezing.
    5. Aeration.
- C. Removing hardness.
    1. Heating.
    2. Addition of softening agents.
    3. Demineralization.
- D. Laboratory methods.
    1. Distillation.
    2. De-ionization.
- E. Conversion of salt water.
    1. Multiple-effect.
    2. Flash evaporation.
    3. Vapor-compression distillation.

XIII. Future Water

A. Problems.

1. General lowering of the water tables in every section of the United States due to increasing demands by home and industry.
2. Increase in floods.
   Example: Despoilation of forests and vegetation for open-pit mining, highways, buildings, etc.
3. Decreasing number of permanent streams.
4. Silt-loaded streams and rivers.
5. Increased pollution of water resources at a rate much like our population increase.
6. Difficulty in filling present reservoirs and the lack of efficient conservation of reservoir sites.

B. Remedies.

1. Realize the existence of the problem.
2. Understand the cause of the problem.
3. Have a desire to correct the problem.
4. Research.
5. Educate the public.

LEARNING ACTIVITIES AND MATERIALS

I. Learning Activities

A. Demonstrations.

1. Perform a distillation experiment to illustrate the evaporation, condensation, and purification parts of the water cycle.
2. Show the three states of water: solid, liquid, and gas. Note that water expands when it freezes.
3. Place salted water in a test tube. Let the water boil. Hold a spoon near the top of the tube. The salt does not evaporate with the water. Taste the water.
4. Demonstrate and discuss the evaporation phenomena in a closed container, open container, heated container, and in moist and dry air.
5. Take two quart jars and place fresh water in one, boiled water (cooled) in the other. Place a fish in each jar. The fish in the boiled water will come to the surface for air. This illustrates that normal fresh water contains air (oxygen).
6. Fasten two microscope slides together with rubber bands. Place them on edge in a pan of ink. The ink will move up between the two slides by capillary action.
7. Demonstrate the hydrologic cycle by tightly sealing a terrarium and placing it in the sunlight.
8. Streak agar plates with water samples from various sources, incubate, and examine for bacteria colonies.
9. Fill a standard electrolysis apparatus with water slightly acidified with diluted sulfuric acid. Close the stopcocks on the apparatus and then pass a D.C. current of electricity through the apparatus for a few minutes. Note the relative amounts of gases which collect at the anode and cathode.
10. To show the effect of surface area on the rate of evaporation, place 500 c.c. of water into a graduate cylinder, a beaker, and a pie pan. Place on a shelf for observation over a period of several weeks. Note the amount of evaporation in each. Which evaporates first? Last? Explain.
11. On a sunny day when the sun is shining on part of the blackboard, use a wet sponge to make a moist spot on the board where the sun is shining and another similar spot on a portion of the blackboard not heated by the sun. Which dries first? Why?
12. Place several ice cubes in a drinking glass and add cold water. Observe the glass carefully for five to ten minutes. Explain.
13. Collect a pint (approximate) of fertile soil. Immediately weigh the soil and record the weight. Now spread the soil out on a newspaper for several days and weigh again. Explain the difference.
14. Surface tension: (A) Secure a dry drinking glass and a pound of lead shot

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(B.B.). Fill the glass level full of water, but do not let any water run over the edge. Carefully add the lead shot, one at a time, to the glass of water. With care, a large number of shot can be added without spilling any water. Note the surface of the water is convex and slightly above the rim of the glass. Explain. Now touch the top edge of the glass. (B) Put a thin layer of vaseline over a paper clip and carefully place the flat surface of the clip on the water. If carefully done, the clip floats on the water. Explain. Using a medicine dropper, place a drop of liquid soap on the surface of the water near the paper clip. The clip sinks. Explain.

15. Secure 500 c.c. of distilled water (may use rain water) and 500 c.c. of hard water. (If your water supply is naturally soft, add 1/4 of a spoonful of calcium sulphate.) Also secure two quart bottles, a medicine dropper, and some liquid soap. Place the hard water in one bottle and the soft water in the other bottle. Add one drop of soap to each bottle and shake. Continue to add soap, one drop at a time, until soap suds form in each bottle. How many drops were needed to form suds in the soft water? In the hard water? Why? (Note: The more minerals the water contains, the "harder" it is.)
16. Breathe on a cool mirror or a cool, dry piece of glass. Note the thin film of moisture forming on the glass. Where did it come from?
17. Secure a glass beaker containing 100 c.c. of water and add a spoonful of sugar. Stir with a glass rod until dissolved. Add sugar until no more can be dissolved. How much was dissolved? Repeat using salt, sand, etc. Is there a difference in solubility? Why?
18. Fill three small beakers with gravel, sand, and clay respectively. By pouring measured amounts of water into the beakers, determine which material holds the greatest amount of water.
19. Compare the permiability of gravel, sand, and clay by putting each material into a funnel (lined with filter paper) and then note the time required to pour a given amount of water through the funnel.
20. Pour 10 ml. of aluminum sulfate and 10 ml. of lime water into 100 ml. of ordinary tap water. Add a small amount of ammonium hydroxide as a catalyst. Note the flocculent precipitate which is formed and then discuss how coagulation aids in the purification of water.
21. Add one drop of diluted hydrogen sulfide solution to 50 ml. of water. Pass the resulting solution through a filter paper half full of activated charcoal. Examine the filtrate for any trace of odor.
22. Place a thermometer in an ice-water mixture and note the freezing point of water. Also note the barometric pressure. Compare the values obtained to the accepted values for the freezing point of pure water (0° C.) and the boiling point of pure water (100° C.) under normal atmospheric pressure.
23. Determine the density of water by carefully weighing exactly 50.0 ml. of distilled water. Note the temperature of the water. Compare the value

obtained experimentally to the accepted value.

24. Secure a gallon metal can and fill with a mixture of cracked ice (4 parts) and salt (1 part). When filled with this mixture, carefully watch the surface of the can for any changes that take place (frost formation).
25. Place a small piece of sodium metal into an evaporating dish that is half full of water (Caution: Sometimes a slight explosion scatters particles of sodium that are caustic to the skin.) After the reaction is completed, test the resulting solution by dipping a glass stirring rod into the solution and then touching it to a piece of red litmus paper. Discuss the fact that active metals, such as sodium, react with water to form bases and hydrogen gas.
26. Place a small amount of magnesium oxide into a test tube containing approximately 20-30 ml. of distilled water. Test the resulting solution with red litmus paper. Discuss the fact that metallic oxides react with water to form metallic hydroxides or bases.
27. Place a small amount of phosphorus pentoxide into a beaker half full of water. Test the resulting solution with blue litmus paper. Discuss the fact that non-metallic oxides react with water to form non-metallic hydroxides or acids.

B. Field trips.
   1. Visit a city water supply plant.
   2. Visit a water power plant (hydroelectric).
   3. Visit a sewage disposal plant.
   4. Visit a well-managed watershed.
   5. Visit a local farm practicing approved conservation practices. (Note the water control methods used--irrigation.)
   6. Go out after a heavy rain and observe evidence of water erosion.
   7. Visit industrial plants in your community and note how the wastes and water is disposed.
   8. Visit a local cave.
   9. Visit a local stream to check for indications of pollution.
   10. Visit a pond, stream, and swamp to note the ecology of the area. Compare the flora and fauna and the water of each area.

C. Discussion.
   1. Discuss the water resources available to your own community as to:
      a. Adequacy.
      b. Use.
      c. Purification.
      d. Sewage treatment.
      e. Present pollution.
   2. How did the streams and lakes contribute to the early settlers?
   3. Did the early settlers have to worry about water pollution? Why?
   4. How do forests relate to even flow of streams?
   5. Has civilization increased or decreased the amount of water stored in the

earth? Why?

6. Discuss the contribution which water makes to the tourist industry of Pennsylvania. Will pollution harm the economy of Pennsylvania? Why?
7. Discuss the different forms of precipitation and the conditions that must be present for formation of them (hail, sleet, rain, snow, frost, and dew).
8. Discuss high and low pressure areas and their effect on weather.
9. Discuss federal government participation on water power projects.
10. Explain ways in which water is being polluted at the present time and tell of the disastrous results.
11. What is the relationship of water to plants, animals, and people?
12. Is there much industrial use of water in your area? Are industrial uses in competition with each other or with other uses? Why?
13. Discuss the three states of water: solid, liquid, and gas.
14. Discuss why the ocean is salty.
15. Discuss methods of retaining water in a watershed area.
16. Discuss all forms of water recreation in which the students have taken part.
17. Why does ice float on water if materials contract as they cool? (Water is most dense at 4^{o}C. 39^{o} F.).
18. Discuss the effects of forest fires on watershed, water supply, and flood conditions.
19. Discuss the dependence of all living things on an adequate water supply.
20. What new sources of water are there--regulations limiting use, reuse, de-salting sea water, and better utilization of present supply by new sewage techniques?
21. Discuss agencies which have some control of water supply and use in the community: water, health, park, and highway departments and soil conservation districts.
22. Discuss the ways in which the various uses of water often conflict with one another:
    a. Drainage vs. waterfowl habitat.
    b. Municipal or industrial waste disposal vs. swimming, fishing, and boating.
    c. Power development vs. lake level stabilization.
    d. Private water rights vs. public needs.
23. Discuss the problem of detergents polluting streams. What is the major problem of detergent pollution?
24. Where does your community get its water? Can the supply and quality of the water be improved?
25. How does your community dispose of its sewage? Can this method be improved?
26. Does sewage disposal treatment cost money or save money over a period

of time?

27. Is it wise to use detergents?
28. What is the T.V.A. (Tennessee Valley Authority)?
29. Does a property owner own the water that flows across his land?
30. How has water caused trouble between Israel and the Arab nations?
31. Debate:
    a. That other projects like the T.V.A. should be developed in other river basins under federal sponsorship.
    b. Control of water pollution is a state and federal problem.

D. Bulletin board displays showing:
1. The water cycle.
2. Good water management practices.
3. Poor water management practices.
4. The many uses of pure water.
5. A stream polluted near its source. Show the effects on humans, fish, and wildlife as polluted water moves downstream.
6. Water safety rules in general and specific safety procedures for each water activity.
7. Plants that grow in the water.
8. Animals that live in the water.
9. How water can be purified.
10. The important canals in America.
11. The major streams of your county, state, nation, and the world.
12. Where federal dams and power projects are located.

E. Student activities and projects.
1. Make drawings to illustrate the various types of water systems in rural homes:
    a. Gravity system.
    b. Shallow well type.
    c. Deep well type.
2. Make a drawing to illustrate the movement of water in the water cycle.
3. Make a diagram of a water softener and explain its operation.
4. Plan a program for water purification in your home and community.
5. Make a diagram showing the rock strata and soil layers which make artesian wells possible.
6. Write the story of a river. Tell of its source, the cities it passes through, the rural areas, the life it supports, the uses made of it, the abuses it suffers, and how it should be used.
7. Ask your county agent if you have Public Law 566 Watershed Projects in your area. If so, visit one of these watershed projects and make a study of water control features and practices included in the watershed practice plan.
8. Develop a balanced aquarium to show the relationship between plants, animals, and water. Why must plants be present? What contributions do

animals make?

9. Compare a drop of pond water with a drop of water from the faucet under the compound microscope.
10. What can we do to encourage water conservation?
11. Find out how much water is consumed in your area daily. (Contact the local water board.) Find out the rate of population expansion. (Contact the local Chamber of Commerce.) Will the present water supply meet future needs? Discuss possible new sources of water.
12. Using a U.S.G.S. topographical map, determine the boundaries of the watershed in which you live. Also trace the drainage system of the watershed.
13. Show the importance of water to plant growth by growing a plant in moist soil (keep soil moist by watering) and by growing one in dry soil.
14. Collect water from a leaky faucet for a definite period of time in a measuring container. Compute the amount of water lost in 24 hours and in one year. Obtain the cost of water and compute the cost of a leaking faucet for one year.
15. Make and demonstrate how a water wheel works.
16. Explain how a pond freezes during the winter months. Consider the following questions: (1) What is the temperature of the water in the pond when the water has its greatest density? (2) Why does the pond freeze from the top and not from the bottom? (3) Why does the pond usually not freeze solid?
17. Construct two model watersheds--one showing good water conservation principles and the other poor practices.
18. Construct a model illustrating irrigation methods.
19. Write a paper explaining the old Chinese proverb: "To rule the mountain is to rule the river".
20. Write a report on water conservation in your own area.
21. Write a paper on the importance of water transportation in American history.
22. Write a paper on the leisure and recreational uses of water.
23. Write a report on how water has influenced our economic development.
24. Report on newspaper and magazine accounts of recent floods and what could have been done to prevent the floods.
25. Find the locations of salt-water conversion plants now operating in the United States and describe the various methods used for conversion of salt water to fresh water.
26. Determine when we use the most water in our homes and cities and show the relationship of seasonal demands to seasonal supplies. (All of this information could be plotted on a graph for one year.)
27. Plot evening water consumption (as determined from local pumping stations) against the time. There will probably be a relation to television commercials.

II. Learning Materials

A. Audio-visual materials.

1. See list of sources at the end of the guide.

B. Books and pamphlets.

1. Baldwin, Helene L. and McGuinness, C. L., A Primer on Ground Water, U. S. Geological Survey, Washington, D. C. 20242.
2. Callison, Charles H., America's Natural Resources, Ronald Press Company, New York, 1957.
3. Carhart, Arthur H., Water - Or Your Life, (revised edition), J. B. Lippincott Company, Philadelphia, 1959.
4. Carson, Rachel L., The Sea Around Us, Oxford University Press, New York, 1951.
5. Chang, L., The Archaeology of China, 1965.
6. Cheyney, E. G. and Schantz-Hansen, T., This Is Our Land, Webb Publishing Company, Saint Paul, 1946.
7. Clawson, Marion, Man and Land in the United States, University of Nebraska Press, Lincoln, 1964.
8. Clepper, Henry, Origins of American Conservation, Ronald Press Company, New York, 1966.
9. Colman, E. A., Vegetation and Watershed Management, Ronald Press Company, 1955.
10. Cottrell, L., The Anvil of Civilization, Mentor Books, 1956.
11. Crosby, Alexander L. and Larrick, Nancy, Rivers - What They Do, Whitman Publishing Company, Racine, Wisconsin, 1961.
12. Dohrs, Sommers, and Petterson, Outside Readings in Geography, Crowell Company, New York, 1955.
13. Ellis, Cecil B., Fresh Water from the Oceans, Ronald Press Company, 1955.
14. Helfman, Elizabeth S., Land, People, and History, David McKay Company, Inc., New York, 1962.
15. King, Thomas, Water Miracle of Nature, MacMillan Company, New York, 1953.
16. Kuenen, Philip H., Realms of Water - Some Aspects of Its Cycle in Nature, J. Wiley and Sons, 1955.
17. Langbein, W. B. and Hoyt, W. G., Water Facts for the Nation's Future, Ronald Press Company, 1959.
18. Lewis, Alfred, This Thirsty World, McGraw-Hill Company, 1964.
19. Leopold, Luna B. and Langbein, Walter B., Primer on Water, U. S. Geological Survey, Washington, D. C., 1960.
20. Mason, Brian, Principles of Geochemistry, J. Wiley and Sons, 1966.
21. McGuinness, The Role of Ground Water in the National Water Situation, U. S. Geological Survey, Water Supply Paper 1800, Paper Cover-$4.50, U. S. Government Printing Office, Washington, D. C. 20402.

22. Milne, L. J. and Milne, Margery, Water and Life, Atheneum Press, 1964.

23. Musil, A. and Glubb, J. B., The Complicated Lives of Desert Nomads in Coon, ed., Readings in Anthropology, Holt Rinehart and Winston, 1965.

24. Perry, John, Our Polluted World, Franklin Watts, Inc., 1967.

25. Ramsey and Burckley, Modern Earth Science, Holt Rinehart and Winston, 1965.

26. Rasmussen, K., The Seal Eskimos in Coon, ed., Readings in Anthropology, Holt Rinehart and Winston, 1963.

27. Stenning, D., The Pastoral Fulani of Northern Nigeria in Gibbs, ed., Peoples of Africa, Holt Rinehart and Winston, 1956.

28. Steward, J., Handbook of the American Indian, Smithsonian Publications, 1945.

29. Turnbull, C., The Forest People, Natural History Press, 1961.

30. Whitaker, J. Russell and Ackerman, Edward A., American Resources, Aarcourt, Brace and Company, New York, 1951.

31. America's Shame - Water Pollution, Educational Servicing Section, National Wildlife Federation, 1412 Sixteenth Street, N. W., Washington, D. C. 20036.

32. Clean Water - A Challenge to the Nation, U. S. Department of Agriculture, Washington, D. C., 1960.

33. Swamp, Marsh, or Bog - Nature's Rain Barrels, The Garden Club of America Conservation Committee, 598 Madison Avenue, New York, New York 10022.

34. Water, Educational Servicing Section, National Wildlife Federation, 1412 Sixteenth Street, N. W., Washington, D. C. 20036.

35. What Is a Watershed?, U. S. Department of Agriculture Soil Conservation Service.

36. Water Pollution - Civilization's Needless Tragedy, The Garden Club of America Conservation Committee, 598 Madison Avenue, New York, New Yor, 10022.

37. Water - Riches or Ruin, Doubleday, 1959.

38. Water, The Yearbook of Agriculture, U. S. Department of Agriculture, Washington, D. C., 1955.

AIR

BACKGROUND INFORMATION

Air, water, and food are the three materials needed to sustain life as we know it. Without foood, a human might be able to exist forty or fifty days; without water, for as long as five or six days; but without air (oxygen), a person becomes unconscious within fifteen minutes and death occurs within thirty minutes. In other words, each person requires four and one-half pounds of water, two and three-quarter pounds of food, and thirty pounds of air per day. On this basis, air is the most important requirement of life.

Fortunately, air is very abundant over the surface of the earth. It forms layers varying in composition to a height of approximately six hundred miles. The atmosphere encircles the entire earth and penetrates into the cracks and crevices between soil particles and is in solution in every body of water. The density is the greatest near the surface of the earth and decreases as the outer limits of the atmosphere are reached. In fact, approximately ninety-nine per cent of the air is found in the first three miles of the atmosphere. It is convenient to think of terrestial life as existing in or at the bottom of an ocean of air.

One theory is that the earth was a molten mass of incandescent material during the first stages of formation. The heavier elements, such as iron and nickel, sank to the center of the mass. Surrounding this, a fluid layer of lighter elements, such as aluminum, phosphorus, nitrogen, and carbon, comprised the outermost layer. As this layer cooled, the elements combined to form molecules of hydrogen (H_2), water (H_2O), methane (CH_4), ammonia (NH_3), carbon dioxide (CO_2), and hydrogen cyanide (HCN) which formed the early atmosphere. Since there was an excess of hydrogen which readily combines with oxygen, no molecules of oxygen were present in the first atmosphere.

As the atmosphere cooled, it is speculated that some of the water vapor began to condense and fell onto the heated rocks only to be converted back to steam and returned to the air. However, this had a cooling effect on the rock surface, and in time (millions of years), the surface rocks cooled to the point where water began to accumulate in the low areas. As the seas enlarged, some of the gaseous materials of the atmosphere dissolved in the warm waters forming a complex mixture of chemicals from which, it is believed, early life originated. In time, much of the carbon became incorporated into the organic compounds of living organisms, and competition for food became critical.

It is thought that when the first photosynthetic organisms evolved, the amount of oxygen in the air increased, carbon dioxide concentration decreased, and the food crisis for early organisms was lessened. This transition required a very long period of time, and it is impossible to pinpoint the exact geological period when it happened.

The oxygen released by the photosynthetic process began to accumulate. Oxygen is a very active element and immediately reacted with other elements causing what is referred to as the oxygen revolution. Oxygen combined with methane to form carbon dioxide and water, with ammonia to form nitrogen and water, and with aluminum and silicon to form silicates--the basis of most of the rocks today.

As a result, methane, ammonia, hydrogen cyanide, and much of the carbon dioxide was removed from the atmosphere. Much of the free hydrogen, being very light, was lost into outer space. Oxygen and nitrogen began to accumulate in the atmosphere. Nitrogen, being less reactive than oxygen, accumulated to a greater extent than did oxygen. This led to an atmosphere of approximately 78% nitrogen, 20% oxygen, 0.03% carbon dioxide, and inert gases and water vapor.

Another popular theory is the belief that the components of the atmosphere have been largely, if not entirely, exhaled from the interior of the earth primarily through volcanism. This theory, currently drawing the attention of scientists attempting to explain the evolution of the earth's atmosphere and oceans, would favor the idea that the earth's earliest atmosphere originated from gases occluded or combined within the solid materials which aggregated to form the planet Earth. These gases were later released by heat and chemical reactions accompanying and following aggregation. This process is popularly referred to as "degassing".

Early atmospheric components were probably methane and hydrogen with smaller amounts of water, nitrogen, and ammonia.

Paleonthologic and geochemical evidence indicates that green plant photosynthesis existed at least 1.7 to 2.0 billion years ago, and that atmospheric oxygen began to be available in large quantities about 1.2 billion years ago. When there was sufficient oxygen present for it to become a stable component, the atmospheric ammonia was oxidized to nitrogen and the methane to carbon dioxide. It is felt that the "build up" in oxygen in the atmosphere was quite gradual and did not reach its present concentration until late in earth history.

By the end of the Carboniferous period when green plants were flourishing (as estimated by the large coal deposits of this age), the earlier excess of carbon dioxide was used by plants; and the air was probably not very different than it is today. Since then, the job of stabilizing the air to a composition as we know today has been left to the green plants, the oxygen-using organisms, and the oceans (where marine micro-organisms near the surface produce seventy per cent of the world's photosynthetic oxygen).

Man is changing the air today more than any other factor on earth.

The nitrogen in the air is a colorless, odorless, and tasteless gas. It is only slightly soluble in water and has a density of 1.25 grams/liter at standard temperature and pressure. Although nitrogen is not classified as an inert gas, it is very inactive with respect to chemical activity. Atmospheric nitrogen is of little value, but the compounds containing nitrogen play a vital role in the chemistry of today's world. As electricity passes through the air, it can convert atmospheric nitrogen into soluble nitrogen compounds which benefit agriculture. The roots of legume plants contain "nitrogen-fixing" bacteria which have the ability to take nitrogen from the air and convert it into soluble nitrates. The plants can then use these soluble nitrogen compounds to manufacture plant proteins which, in turn, are consumed by animals to build tissues. The living cells of the animals contain proteins rich in nitrogen.

Oxygen gas is colorless, odorless, and tasteless. It is slightly soluble in water. In direct contrast with nitrogen, oxygen is an active element which combines readily with most metals to form oxides. Oxygen is a life-sustaining gas required by animals for respiration. It is also an excellent oxidizing agent. Bacteria in water may be killed by spraying the water into the air. This process is called aeration.

Ozone is found primarily in a layer within the stratosphere and is responsible for ultraviolet radiation absorption. If this absorption did not take place, the radiation at the earth's surface would be fatal for most forms of life.

Carbon dioxide occupies only 0.03% of the air by volume. There would be no plant life without it. All green plants require carbon dioxide during photosynthesis to build sugar.

Much carbon dioxide is used every year for the production of carbonated beverages. The solubility of carbon dioxide in water is increased with an increase in pressure. Carbon dioxide is used in making dry ice, and since it is heavier than air and will not burn, is used in fire extinguishers.

The inert gases constitute approximately one per cent of the total volume of the atmosphere. Argon is the most abundant of the inert gases and is used to fill electric light bulbs. Helium is another inert gas which does not take part in chemical changes. It is very light and has a great lifting force. Helium is used for scientific experiments which require inert atmospheres. As a result of its importance, the production of this gas is under control of the federal government. Neon is present in the air to the extent of about eighteen parts per million by weight and is used extensively in neon signs.

Water vapor is found in the air in varying amounts. Air is saturated when it contains its maximum amount of water vapor. The amount of water vapor present in the air compared with the amount that would be present if the air were saturated is called relative humidity. A relative humidity between forty-five and fifty-five per cent is desirable for maximum body comfort.

The preceding represents the average composition of the air, and it should be stressed that over the entire surface of the earth, this per cent composition remains remarkedly constant. However, there are certain limited areas or seasons in which a certain amount of variation may exist.

During the growing season, the amount of pollen in the air increases. During June in the northern United States and Canada, the pollen from various evergreens takes a sudden jump. Likewise in August and early September, the pollen from ragweed (a common cause of hay fever) reaches its peak.

The amount of smoke, sulfur dioxide, and hydrocarbons surrounding industrial areas are usually higher in the winter than at other times.

The per cent of carbon dioxide may be lower in areas of extremely dense vegetation due to the photosynthetic process.

As noted above, air is a mixture of several different compounds and elements. The properties of air are a result of the composite properties of its component parts.

Although the atmospheric composition has not changed appreciably during the last hundred million years, there is now some concern over man's influence on the environment. Mason (1966) estimates that the total carbon dioxide produced annually by the burning of coal and oil is about 1/300 of the amount already in the atmosphere. This suggests that at the present rate of consumption of fossil fuels, atmospheric carbon dioxide will be doubled in three hundred years.

At the same time, in the United States alone, we are paving nearly a million acres of green plants each year and removing them from the photosynthetic cycle. This contributes to the increase of carbon dioxide in the atmosphere and decreases the amount of oxygen.

Carbon dioxide in the air reduces the amount of heat lost into outer space by infrared radiation. An increased amount of carbon dioxide in the air would result in a higher temperature. It is thought that an increased amount of carbon dioxide in the atmosphere during the Carboniferous period 300,000,000 years ago is believed by some geologists to have been responsible for the semi-tropical climate that prevailed over much of the earth at that time. This "trapping" of heat by carbon dioxide is referred to as the "greenhouse effect". At the present time, due to the widespread use of coal and petroleum during the first half of this century, the carbon dioxide content of the atmosphere is increasing. It is estimated that the carbon dioxide content of the air increased by twelve per cent between 1800 and 1950. If this trend continues for another one thousand years, there could be a shift from a temperate to a semi-tropical climate on a world-wide basis.

As mentioned above, increasing carbon dioxide concentration will lead to a general rise in the earth's temperature.

One group states that an increase in temperature will melt the ice caps and raise the sea level by as much as three hundred feet. This will flood most of the major cities of the world.

Another school suggests that higher temperatures will cause an increase in evaporation, more precipitation, additional snow falling on the ice caps, and another ice age.

We have little information or knowledge concerning whether or not man has had any serious effect on the nitrogen cycle.

Live plants, including bacteria and algae, use nitrogen to build proteins; animals build proteins from plant proteins; nitrogen is released again to the atmosphere from decaying organic matter as nitrogen and in the form of ammonia. The rates of use and return of nitrogen have reached a balance so that the per cent of nitrogen in the atmosphere remains constant.

Man could be disrupting this cycle by adding nitric oxide to the atmosphere from high-temperature combustion processes, such as occurs in the automobile.

The disruption of this cycle in one way or another could cause the disappearance of nitrogen. It might be replaced by poisonous ammonia, or it might remain in the atmosphere in a form unusable for plant life. A clear need for research is evidenced by the fact that man does not know what will happen.

Air is colorless, tasteless, and odorless except for dust, spores, ammonia, or contamination by various industrial and domestic pollutants.

Air expands when heated (Charles' Law) and is compressed when under pressure (Boyle's Law).

At sea level, air has a density of 0.08 lbs./cu. ft. and exerts an atmospheric pressure of 14.7 lbs./sq. in. This represents the weight of a column of air one inch square extending out into space as far as the atmosphere exists. Pressure itself is defined as force per unit area. The force exerted by the air is synonymous with its weight. As one increases in altitude, the amount of air above a given area is less; consequently, the air pressure is less.

Pressure also has a horizontal distribution at a given elevation. Atmospheric pressure distribution is represented by isobars which are lines connecting places having the same atmospheric pressure at a given elevation. The rate and direction of change in pressure is called the pressure gradient.

If the pressure within a tire or other inflated device is measured with a pressure measuring gauge, the reading obtained is called a gauge pressure and is the pressure exerted above that normally exerted by the atmosphere. In other words, a gauge pressure of 30 lbs./sq. in. is an absolute pressure of 44.7 lbs./sq. in. (30 + 14.7).

The density and weight of a given volume of air varies with temperature. When air is heated, it expands and becomes less dense. Such temperature changes set up vertical and horizontal movements resulting in differences in atmospheric pressure. Other factors, such as friction or centrifugal force, exert an effect upon air pressure.

Air pressure is affected by velocity of the air. According to Bernoulli's principle, the pressure of a moving fluid, such as air, is less when the velocity is high and greater when the velocity is lower.

As we progress upwards into the atmosphere, the pressure decreases; and as a result, the air is less dense. Correlated with this are several changes in the chemical and physical properties of the air. As a result, it is convenient to think of the atmosphere as made up of various layers.

From sea level to a height of six to seven miles is the troposphere layer. This is the only layer where the weather occurs and is characterized by variations in temperature, strong winds and air currents, and the presence of water vapor. Life is restricted to this layer.

The tropopause can best be defined as a transition stage between the troposphere and the stratosphere. The stratosphere extends from seven miles to sixty miles above sea level and is made up of several strata. This layer is characterized by an absence of clouds (no water vapor), winds or air currents, life, and uniform temperature at any given level. The lower stratum of the stratosphere is very cold. Above this (from twenty to forty miles above sea level), the per cent of ozone is higher due to the action of ultraviolet light on the oxygen. The temperature of this ozone layer is much higher.

The ionosphere extends from sixty to one hundred miles above sea level and is characterized by a rarefied atmosphere, a warm temperature, and the presence of many ionized particles.

The outer layer of the atmosphere is called the exosphere and is a transition layer from the earth's atmosphere to outer space extending from sixty to six hundred miles above sea level.

An air mass may be defined as a vast part of the atmosphere that has similar properties throughout. The properties of an air mass depend upon the area over which it originates. If an air mass originates over water, it is referred to as maritime; and if it originates over land, it is called a continental air mass. Maritime and continental air masses may either be polar and contain cold air or tropical and contain warmer air. Frequently, continental polar air masses bring cold air down over the United States. Maritime tropical air masses form over the tropical regions of the south and are the warmest and bring the most moisture into the United States. Quite often, a maritime tropical moves northward after a continental polar has moved southeastward across the states. The sloping boundary between two air masses of different temperatures is called a front. The greatest weather changes take place in these fronts.

Wind is the movement of air from a region of high pressure to a region of low pressure. It is caused by the unequal heating of the earth's surface. The direct rays of the sun at the equator are more effective in increasing the temperature than the slanting rays of the sun as we progress poleward either north or south. Land surfaces will heat faster than the surface of a body of water. Exposed soil surfaces heat faster than ones covered with vegetation.

As the surface of the earth is warmed, the air directly above it also heats up thus creating a low pressure area. The lighter air in a low pressure area is forced up as heavier air from a high pressure area moves in under the lighter air.

The outline discusses the several wind patterns of the earth. The world-wide pattern of winds is greatly modified by certain local conditions.

Cool winds that flow downhill during the night to replace the warm air of lowland areas are called slope winds.

Sea and land breezes flow from the sea to land by day and from land to sea by night. Coastal slope winds are found where high mountains adjoin warm coastal areas as along the Adriatic Sea. Here, cold mountain air frequently descends down the mountainside and out into the sea causing frequent high waves.

Dry, cold winds which descend down a river valley into moist, warm coastal areas are called mountain gap winds.

Mountain and valley winds are those that flow toward and up a mountain slope during the day and downward during the night.

Wind on the lee side of a mountain (Chinook or Foehn) is warm and dry. Any moisture that was present in the air was removed as the wind passed over the mountain due to the sudden gain in elevation and the resulting decrease in temperature. As the dry air descends, it is compressed which has a heating effect on the wind.

The monsoon winds are seasonal winds that blow from a moist sea area onto dry land during the summer bringing heavy rain with it. During the winter or dry season, this is reversed, and the wind blows from the land out over the sea.

By subjecting air to high pressure and low temperature, it is possible to convert air to a liquid state. The increased pressure crowds the gas molecules together, and the lowered temperature slows down their movement. Ultimately, the molecules are slowed down and crowded together so closely that the attractive forces between the molecules cause them to condense to a liquid. It is first necessary to compress the gas and then to absorb the heat of compression. The cool, compressed gas is then permitted to expand rapidly through an expansion valve. During the expansion, the gas molecules lose energy as they spread out and, as a result, decrease in temperature.

The temperature to which any gas must be cooled before it can be liquified is called its critical temperature. The pressure required to liquify a gas at its critical temperature is called its critical pressure. The critical temperature of air is 140.7° C., and the critical pressure is 37.2 atmospheres.

Liquid air boils at a temperature of about -190° C., but it is a mixture and as such has no definite boiling point. As liquid air boils, the nitrogen boils off at -196° C. and oxygen at -183° C.

The effects of air pollution are listed in the outline. The major problem concerning air pollution is that most of the health problems are long-term situations and difficult to notice until it is too late. The other problem is that we tend to allow financial reasons to overrule biological concerns. One example will illustrate the subtle effects of air pollution. In some cities, it is so bad that it is reducing the oxygen content of drivers' blood and causing automobile accidents. The reduction of oxygen in the bloodstream is caused by carbon monoxide. Carbon monoxide unites with the hemoglobin more readily than oxygen; therefore, it causes a reduction in the oxygen carrying capability of the red blood cells. This results in less oxygen being supplied to the body cells and causes the organism to react more slowly and less efficiently. Already there is statistical evidence of an increase in traffic accidents in Los Angeles during certain months when measured pollution levels are relatively high.

Classification of air pollutants is a difficult task. Pollutants are produced by our transporation system, manufacturing concerns, electric power generation, space heating, and refuse burning.

Although air has a great capacity for coping with pollutants, it is not limitless. The portion of the earth's atmosphere available to dilute air pollution is confined to the bottom layer about six miles thick. Within this layer (70% of the total air mass) are the complex wind systems and other factors which establish ventilation rates and patterns. These are non-uniform in time and space, varying seasonally, diurnally, and with such factors as topography, weather, and solar radiation. Such a limited air space is not sufficient to dilute and disperse the air pollutants which are being poured into the skies.

Natural forces over eons have contaminated the air with sand and dust from storms. Volcanic eruptions and forest fires have added tons of gases and particles to the earth's atmosphere. Nature has been known to produce its own form of smog from pine trees. In fact, these volatile hydrocarbons forming a blue haze gave the Smoky Mountains their name. Decaying animals and plants give off gases. Flowers spread pollen. However, this is natural air pollution, and in most cases, nature disseminates this material in such a way that it is no problem.

However, the population is not evenly dispersed over the surface of the earth. People tend to congregate in clusters that result in a concentration of pollutants in a very small part of the atmosphere. For example, more than half of the American people live on just one per cent of the nation's land mass.

Man-made pollution is fast becoming a major health hazard to many areas of the world as illustrated by the patterns of tragedies that have already occurred. Typically, it develops so gradually over a period of years that in many cities, people do not realize that a problem exists.

Perhaps it is not clear to everyone that air is in the public domain; thus, air pollution is a public problem, not only to those who cause the pollution but also to those who may suffer from it.

Air pollution is not just a local problem limited to a town or an area, but it is a global problem because pollution has no particular reason to stop at man-made boundaries.

In the history of man, we find a high correlation between urbanization and industrialization with air pollution. Combustion-induced air pollution is nothing new. Roman togas became soiled by soot and smoke as early as 61 A.D.

As man accelerated his urbanization, pollution problems increased. In 1257, Eleanor of Aquitine, Queen of England, moved from Nottingham to get away from what she called the unendurable smoke. In 1306, the air in London became so bad that King Edward I ordered an end to the burning of coal and even put a coal merchant to death.

The quality of the air is determined by the uses made of the air and by the pollutants injected into it by man.

When wastes are produced rapidly or when they accumulate in such concentrations that the normal self-cleansing or dispersive properties of the atmosphere cannot cope with it, we call the air polluted.

Air pollution became more severe as man learned how to harness the energy released by combustion. As industrial complexes steadily grew along with the industrial revolution, England, Belgium, and Germany continued to have increasing air pollution problems. Air pollution, ironically, has become a needless symbol for a developed society and a high standard of living. The more affluent the society, the more we pollute the air. In a sense, air pollution is the result of the need for heat and power to make vehicles run, for industrial purposes, and to keep our homes warm. Some people conclude that air pollution is unavoidable. This is not true. While all of these forms of burning are necessary, air pollution is caused primarily because of incomplete combustion. Combustion of all kinds can be improved and thus reduce air pollution.

Sulfur dioxide has an irritating, pungent odor and is quite poisonous. It is the chief villain in smog poisoning and is a result of incomplete burning of coal, petroleum, and natural gas.

Carbon monoxide is generally a product of automobile exhausts. It is not usually found in smog because it is not very soluble in water. It is quite deadly because it combines with the hemoglobin in the blood far more readily than oxygen and suffocates the tissues.

Oil refineries and fuels in general produce hydrogen sulfide, a poisonous gas with a rotten egg odor.

A reddish-brown gas which will dissolve in water to produce nitric acid is nitrogen dioxide.

Smog reactants refer to hydrocarbons and oxides of nitrogen which are frequently found in smog.

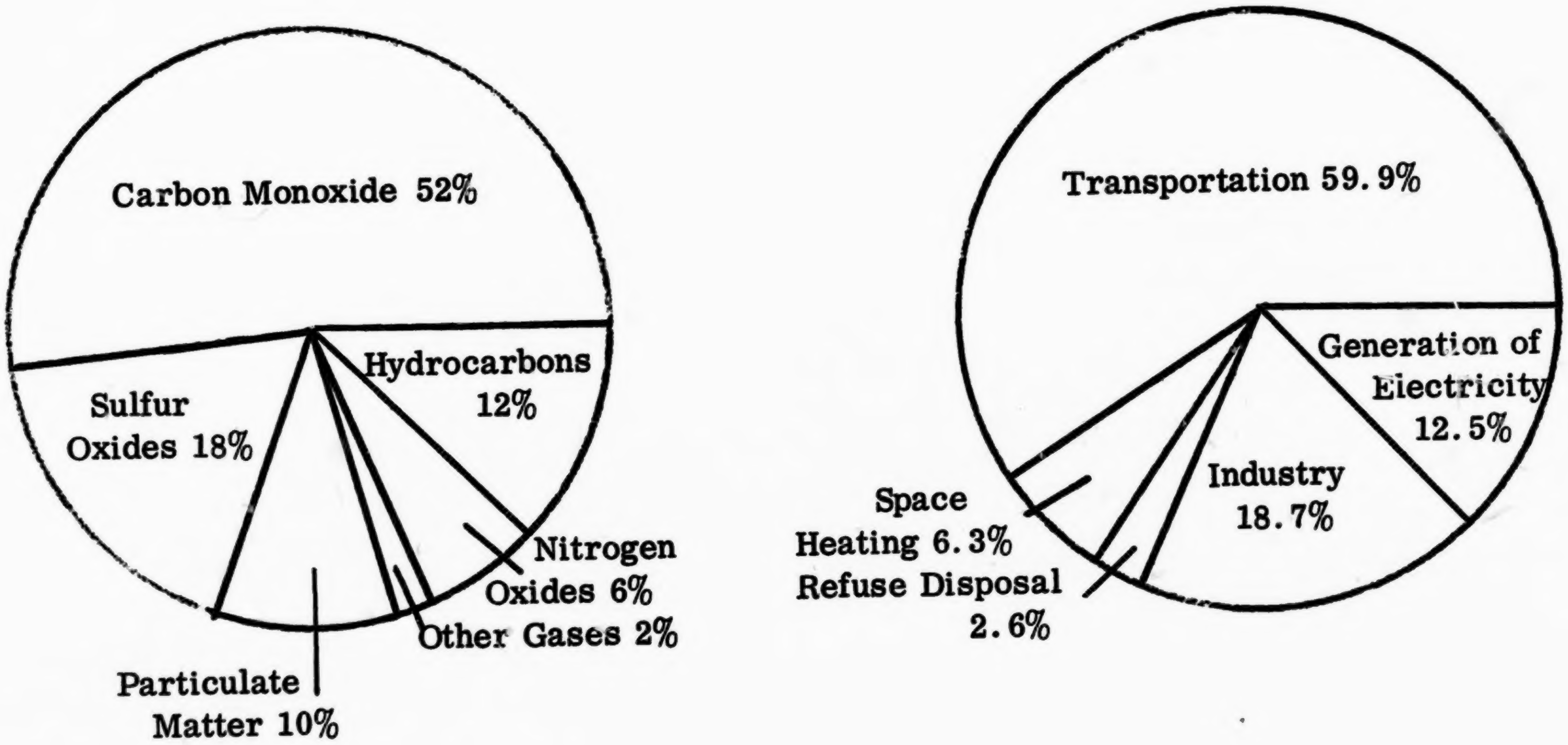
Radioactive pollutants are radioactive particles produced by nuclear reactions.

Carbon dioxide in increased concentration and ragweed pollen would be examples of other pollutants not fitting into any of the other categories.

Pollutants, the materials responsible for air pollution, are produced by nature and by man. Natural sources of pollutants are listed in the outline and need not give us much concern. The deadly and troublesome pollutants are a result of society and, in most cases, can be attributed to the incomplete combustion of coal and petroleum products and to various industrial processes.

The largest single source of sulfur dioxide is that from the generation of electrical power. In 1980, it is estimated that electrical energy will be three times that of 1960 and that an increase of fifty per cent in sulfur dioxide will result. Some of the burden of electrical power generation has been and will be assumed by nuclear reactors. These produce their own brand of hazardous pollution in the form of strontium 90, cesium 136, and krypton 85 among others.

AIR POLLUTION IN THE UNITED STATES*



Type of Pollutant

Source of Pollutant

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*News Focus, "Pollution", October 20, 1967, Vol. 2, No. 4, Newsweek, Inc.

The burning of coal and fuel oil in homes and industry is one of the major sources of air pollution. Another major source is the exhaust from millions of motor vehicles. Automobiles contribute oxides of nitrogen and carbon monoxide to the air. It is estimated that every day, motor vehicles in the United States discharge about 25,000 tons of carbon monoxide and 10,000 tons of nitrogen oxides into the atmosphere. Thus, each car produces about six and one-quarter pounds of contaminants per day.

Other sources of pollutants are forest fires, incinerators, trash fires, and barbecues. In fact, pollutants are released any time a material undergoes incomplete combustion. This even includes the burning of leaves in the autumn.

Although the atmosphere is a vast expanse of space capable of cleaning itself, nature intensifies the pollution problem under certain conditions.

Normally, pollutants are carried high up into the atmosphere by convection currents and are effectively dissipated.

However, if a blanket of warm air moves in over a ground cover of cool air or a cool sea breeze moves in under warm desert air, a "thermal inversion" occurs; and convection currents no longer carry the pollutants into the upper atmosphere to be dissipated. Because of the ceiling of warm air above, there are no convection currents; and the pollutants may accumulate in the cool air below and eventually reach a critical concentration.

A fog is a colloidal dispersion of a liquid in a gas. Both temperature and humidity have much to do with the formation of fog. For a fog to form, the water vapor or other liquid must have something on which to condense. Solid particles of dust or smoke serve very well. Many of the poisonous gases in the air are soluble in water and unite with fog droplets and contribute to the complexity of smog. Smog is essentially moisture condensed around solid particles and combined with dissolved gases.

Air pollution is not the same everywhere. Some air pollution is caused by a single source, such as smoke, dust, or chemical gas. Some forms may be seen, other smelled, and others, such as carbon monoxide, cannot be detected by the senses but are present and dangerous. Photochemical air pollution is caused by the sun shining on a combination of dust, droplets, gases, and chemicals which react and interact to form smog. Photochemical pollution is very prevalent over metropolitan areas.

The London type smog generally results from burning high sulfur-containing fuels, such as those used in heating, smelting, and in the production of electrical power. When fog is present, sulfur dioxide and sulfur trioxide mix with moist air to form sulfuric acid mist. In addition to its harmful effect on animals and plants, it causes deterioration of stone, metals, and fabrics.

The Los Angeles type is caused mainly by automobile exhaust. Bright sunlight causes nitrogen dioxide to react with certain hydrocarbons to produce chemical compounds. Ozone, carbon dioxide, and carbon monoxide are also found in this type of smog.

With approximately six thousand United States communities and every city with a population over 50,000 threatened, sixty per cent of our population is endangered by air pollution. The pollution of air costs the United States an estimated eleven billion dollars per year.

In addition to actions taken by cities (Pittsburgh and Los Angeles, for example) and communities around the country to fight air pollution, the federal government began its program in 1955 with the establishment of air sampling stations. The real fight on a national scale began with the passage of the ninety-five million dollar Clean Air Act of 1963. This provided three dollars in federal money for every one dollar of local money spent to fight air pollution. In 1967, the Air Quality Act was passed with more incentives and more enforcement.

Industry realizes the danger of air pollution and is following its own program. Some states allow tax credits equal to fifty per cent of the cost of installation of air pollution control. One such device is the Cottrell precipitator. This is an electrical device that is placed in the smokestack and attracts charged particles from the smoke.

The foregoing suggests that the time has come for man to stop regarding the atmosphere as unlimited and to undertake its conservation. We are dependent upon the cleanliness of the atmosphere in much the same way as fish are dependent on the relative purity of the water.

Research is currently improving our knowledge of the behavior of the atmosphere, the interaction of it with the oceans, and the various effects of atmospheric pollutants.

Most air pollution problems center on the fact that all creatures live by a process of converting one form of energy into another. Man's process of energy conversion outside of his own body has created an immense volume of pollutant by-products.

A great many of the pollution problems could be solved were it not for the failure to recognize the problems as being national and global rather than local. The flow of air pays no attention to boundary lines.

One major step in air pollution control will be the local government bodies yielding local control to higher governments for state and interstate control. An example of the hodge-podge of governments is represented in the urban area around Philadelphia. It covers eleven counties in parts of three states and contains no less than 377 autonomous municipalities, exclusive of school districts and other special jurisdictions.

Another solution might be to make the polluter financially responsible for maintaining the quality of the air

Major pollution problems in large cities could be decreased by the substitution of electric cars for gasoline-powered automobiles.

Probably the most prominent factor in the fight against air pollution is the fact that people are finally becoming aware of air pollution and the problems involved.

Some people have realized the importance of combating air pollution and are working on the problems. Will we turn the tide? Or will it be as meteorologist Morris Neiburger darkly predicts: "All of civilization will pass away. Not from a sudden cataclysm, but from general suffocation by its own effluents."

OUTLINE OF CONTENT MATERIAL

- I. Origin of the Atmosphere - Theories
  - A. Formation of earth and distribution of elements.
  - B. First atmosphere.
    - 1. Hydrogen.
    - 2. Water.
    - 3. Methane.
    - 4. Hydrogen cyanide.
    - 5. No oxygen.
  - C. Cooling of earth.
  - D. Formation of seas.
  - E. Evolution of first photosynthetic organism.
  - F. Oxygen revolution.
  - G. Accumulation of oxygen and nitrogen in the atmosphere.

- II. Composition of the Atmosphere
  - A. Nitrogen.
    - 1. Per cent composition.
    - 2. Properties.
    - 3. Uses.
      - a. Chemical compounds.
      - b. Nitrogen fixation.
      - c. Important element in animal proteins.
  - B. Oxygen.
    - 1. Per cent composition.
    - 2. Properties.
    - 3. Allotropes - ozone.
    - 4. Uses.
      - a. Breathing and respiration.
      - b. Special occupations.
        - 1. Deep-sea diving.
        - 2. Aviation.
        - 3. Space exploration.
      - c. Oxygen tents.
      - d. Inhalators.
      - e. Sewage purification.
      - f. Burning or combustion.
      - g. Oxyacetylene torch.
  - C. Carbon dioxide.
    - 1. Per cent composition.
    - 2. Properties.

        3. Uses.
            a. Photosynthesis.
            b. Carbonated beverages.
            c. Dry ice.
            d. Baking.
            e. Fire extinguishers.
    D. Inert gases.
        1. Per cent composition.
        2. Properties.
        3. Examples.
            a. Argon.
            b. Neon.
            c. Helium.
            d. Krypton.
            e. Xeon.
    E. Water vapor.
    F. Other materials.
        1. Pollen.
        2. Dust.
        3. Spores.
        4. Bacteria.
        5. Hydrogen.
        6. Methane.
        7. Ammonia.
        8. Carbon monoxide.
        9. Hydrocarbons.
        10. Oxides of nitrogen.
        11. Sulfur dioxide.
    G. Constancy and variability of the atmosphere.

III. Properties of the Atmosphere
    A. Physical.
        1. Greenhouse effect.
        2. Color.
        3. Odor.
        4. Taste.
    B. Chemical.
        1. Oxidation.
        2. Hydration.
        3. Smog formation.
    C. Biological.
        1. Supplies carbon dioxide for photosynthesis.
        2. Supplies oxygen for respiration.

- D. Density of air.
    - 1. Effect of elevation.
    - 2. Effect of temperature.
    - 3. Effect of moisture.
    - 4. Effect of pressure.
- E. Atmospheric pressure.
    - 1. Distribution.
        - a. Vertical.
        - b. Horizontal.
        - c. Pressure gradients.
    - 2. Causes of pressure changes.
        - a. Thermal origins.
        - b. Dynamic origins.
    - 3. Measuring air pressure.
        - a. Devices.
            - 1. Barometer.
                - a. Aneroid.
                - b. Mercurial.
        - b. Gauges and gauge pressure.
        - c. Common units.
            - 1. Lbs./sq. in.
            - 2. Millimeters of mercury.
            - 3. Atmospheres.
            - 4. Millibars.
    - 4. Uses of atmospheric pressure.
    - 5. Uses of air pressure.
    - 6. Laws governing behavior of air.
        - a. Bernoulli's principle.
        - b. Boyle.
        - c. Charles.
- F. Atmosphere stratification.
    - 1. Troposphere.
    - 2. Tropopause.
    - 3. Stratosphere.
    - 4. Ionosphere.
    - 5. Exosphere.
- G. Air masses.
    - 1. Nature of air masses.
    - 2. Major groups.
        - a. Maritime.
            - 1. Polar.
            - 2. Tropical.
        - b. Continental.

        1. Polar.
        2. Tropical.
    3. Fronts.
        a. Cold.
        b. Warm.
        c. Occluded.

H. Winds.
    1. Definition.
    2. General causes of wind.
    3. Wind zones of the earth.
        a. The doldrums.
        b. The trade winds.
        c. The prevailing westerly winds.
        d. The polar winds.
    4. Local wind systems.
        a. Slope winds.
        b. Sea and land breezes.
        c. Coastal slope winds.
        d. Mountain gap winds.
        e. Mountain and valley winds.
        f. Chinook or Foehn winds.
        g. Monsoon winds.

I. Weather.
    1. Effect on plants (see unit on plants).
    2. Effect on animals (see unit on animals).

J. Protective layer.
    1. Absorbs ultraviolet radiation from the sun.
    2. Absorbs radioactive radiation from the sun.
    3. Cushions and burns meteors.

K. Liquification of air.
    1. Factors necessary for liquification.
        a. Critical temperature.
        b. Critical pressure.
    2. Expansion as a cooling process.
    3. Production of liquid air.
    4. Components of liquid air.
        a. Nitrogen.
        b. Oxygen.
        c. Inert gases.
    5. Properties of liquid air.
        a. Boiling point.
        b. Peculiar behavior of materials in liquid air.
    6. Uses of liquid air.

a. Cryogenic research.
b. Cryosurgery.
    1. Ulcers.
    2. Brain tumors.
c. Source of industrial oxygen and nitrogen.

IV. Air Pollution
  A. Symptoms of excessive air pollution.
    1. Smarting or stinging of the eyes.
    2. Irritations in the throat or nasal passages.
    3. An increase in the number of cases of emphysema and chronic bronchitis.
    4. Tomatores, flowers, shrubbery, etc. do not thrive, even in good soil.
    5. Houses need paint every other year.
    6. Nylon and other fabrics do not wear very long.
    7. Leather and rubber deteriorate in a few years.
    8. Curtains and drapes need cleaning several times each winter.
  B. Effects of air pollution.
    1. Diseases.
      a. Chronic bronchitis.
      b. Pulmonary emphysema.
      c. Bronchial asthma.
      d. Lung cancer.
      e. Eye irritation.
      f. Heart disease.
      g. Leukemia.
    2. Oxidation of metallic building materials.
    3. Darkens paints.
    4. Clothing.
      a. Chemical effects.
      b. More washing required.
    5. Plants.
    6. Animals.
    7. Lowers real estate values.
    8. Hinders industrial and municipal developments.
    9. Reduces work efficiency.
    10. Reduces visibility.
    11. Increases carbon dioxide concentration.
    12. Reduces man's work performance.
    13. Increases traffic accidents.
    14. Effects from fallout and radiation.
      a. Somatic.
        1. Leukemia.
        2. Skin cancer.

        3. Bone cancer.
    b. Genetic.
        1. Congenital malformation.
        2. Fetal deaths.
        3. Stillbirths.
    c. Biochemical.
        1. Acceleration of aging process.
        2. Life-shortening effects.

C. Examples of air pollution tragedies.
    1. 1930: Meuse Valley, Belgium - 80 deaths.
    2. 1940: Donora, Pennsylvania - 20 deaths.
    3. 1950: Poza Rica, Mexico - 22 deaths.
    4. 1952: London, England - 4,000 deaths.
    5. 1953: New York City - 200 deaths.
    6. 1956: London, England - 1,000 deaths.
    7. 1962: London, England - 342 deaths.
    8. 1963: New York City - 300 deaths.
    9. Present: Los Angeles - average 100 days of smog/year.

D. Classes of air pollutants.
    1. Fine particles.
        a. Soot.
        b. Fly ash.
        c. Dust.
    2. Poisonous gases.
        a. Sulfur dioxide.
        b. Carbon monoxide.
        c. Hydrogen sulfide.
        d. Nitrogen dioxide.
    3. Smog reactants.
    4. Total oxidants.
    5. Radioactive pollutants.
    6. Others.

E. Sources of pollutants.
    1. Natural.
        a. Volcanic eruptions.
        b. Forest fires.
        c. Turpide haze.
        d. Pollen spread.
        e. Decaying vegetation.
        f. Decaying animal life.
        g. Dust storms.
        h. Cosmic rays (radiation).
        i. Terrestial gamma rays.

2. Man-made.
    a. Industrial waste gases.
    b. Chimney smoke.
    c. Burning trash, leaves, etc.
    d. Automobile and truck exhaust.
    e. Dust from quarries, sawmills, construction, etc.
    f. Application of fertilizers and pesticides.
    g. Incomplete combustion of coal produces:
        1. Sulfur dioxide.
        2. Hydrogen sulfide.
        3. Carbon monoxide.
        4. Smoke.
        5. Soot.
    h. Incomplete combustion of petroleum products produces:
        1. Nitric oxide.
        2. Carbon dioxide.
        3. Hydrocarbons.
    i. Nuclear explosions - radiation exposure.
        1. Exposure from man-made sources.
            a. Medical procedures.
                1. Diagnostic x-rays.
                2. Therapy.
                3. Internal.
            b. Occupational (radiation workers).
            c. Luminous dials.
            d. Color television sets.
        2. Exposure from environment.
            a. Fallout from nuclear devices.
            b. Radioactivity from processing fuels and wastes from nuclear reactors.
            c. Thermal pollution.

F. Nature's intensification of air pollution problems.
    1. Temperature or thermal inversion.
    2. Fogs.
    3. Humidity.
    4. Topographical oddities.

G. Man's labels for dirty air.
    1. Smog and dust.
        a. Smog (smoke and fog).
            1. London type.
            2. Los Angeles type.
        b. Smust (smoke and dust).
        c. Smaze (smoke and haze).

H. Record of air pollution in the United States.
  1. Cost.
    a. Eleven billion dollars per year.
    b. Fifty-five dollars per person.
    c. Will spend three hundred billion dollars by the year 2000.
  2. Abatement program.
    a. Role of federal government.
      1. First air sampling stations.
      2. Clean Air Act of 1963.
      3. Air Quality Act of 1967.
      4. Emission-control devices on all 1968 automobiles.
    b. Methods of combating pollution.
      1. Legislation--local, state, and federal governments.
      2. Enforcement of existing legislation.
      3. Reduction of automobile exhaust.
        a. Fine tuning of engine.
        b. Afterburners.
        c. Catalyst in exhaust system.
      4. Cottrell precipitator.
      5. Filtration.
        a. Ordinary filters.
        b. Chemical filters.
      6. Research programs.
        a. Absorption of pollutants by vegetation.
        b. Evaluation of pollutants from new industrial processes.
        c. Study connections between pollution and respiratory diseases.
      7. Prohibit domestic trash burning.
      8. Local and regional planning groups.
      9. Reduced taxes for industries installing and using air pollution control devices.
      10. Education programs for the public.

V. The Fundamental Problems and the Future

VI. Basic Principles
  A. Air is a mixture of several gases, the most abundant of which are N_2, O_2, CO_2, argon, and H_2O.
  B. Air is cooled as it expands or becomes less dense. Air is heated as it contracts or becomes more dense.
  C. Wind is the movement of air from a high pressure area to a low pressure area.
  D. Air is essential for life. It supplies oxygen for respiration and carbon dioxide for photosynthesis.

E. An increased amount of carbon dioxide in the air speeds up the rate of photosynthesis.
F. An increased amount of carbon dioxide in the air decreases the amount of heat (infra-red rays) radiated into outer space.
G. Warm air is capable of holding more water vapor than cold air.
H. Saturated, warm air loses water by condensation if the temperature decreases.
I. The layer of atmosphere above the earth protects the earth against ultraviolet radiation.
J. Oxygen from the air is essential for combustion to take place.
K. Air pressure is due to the weight of the air above the point where the pressure is measured. Air pressure decreases at high elevations and increases at lower elevations.
L. The air above the earth is stratified into definite layers.
M. Air pollution in the major metropolitan and industrial areas of the world is fast becoming a major health hazard.
N. Incomplete combustion of coal and petroleum products is probably our chief cause of air pollution.

LEARNING ACTIVITIES AND MATERIALS

I. Learning Activities

A. Demonstrations.

1. Using a powerful beam of light in a completely darkened room, note the minute dust particles that become visible in the ray of light.
2. Open a window at the top and bottom. Using a lit candle, determine the flow of air into and out of the room.
3. Secure a gallon can that can be tightly stoppered. Place about two inches of water in the bottom and place over a Bunsen burner so that the water boils vigorously. After steam has been escaping out of the can for about five minutes, screw the cap on tightly so that no air can get in or out. Notice what happens to the can as it cools. Explain.
4. Secure a narrow-mouthed quart bottle. Using a rubber tube and a source of steam, fill the bottle with steam so that very little air remains in the bottle. Quickly place a rubber balloon over the mouth of the bottle. Note what happens to the balloon as the bottle cools.
5. Place a brick endwise on a table and blow at it as hard as possible. Nothing happens. Now place the brick on a paper bag and blow into the bag. What happens? Why?
6. Fill a tumbler level full of water. Place a paper card over the mouth of the tumbler and holding the card in place, invert the tumbler. Now remove the hand from the card. Note that water stays in the tumbler even though it is inverted. Why?
7. Secure about a cupful of fertile soil and place in a graduate cylinder. Add a measured amount of water from another graduate cylinder until the soil becomes saturated. The amount of water used represents the amount of air in the soil.
8. Place a glass jar over a lit candle. Why does the candle go out?
9. Place a balloon over the mouth of a narrow-mouthed bottle. Now heat the bottle. What happens? Why?
10. Using a wide-mouthed bottle, a one-holed stopper, and a thistle tube, pour water into the thistle tube. Results? Repeat using a two-holed stopper. Why the difference?
11. Secure a one-inch square of cardboard and place a pin through it so that the head of the pin is flush with the cardboard. Place the cardboard and pin over the one end of a spool so that the pin is inserted in the hole in the spool. Now blow carefully and steadily into the other end of the spool. Note that the cardboard tends to cling to the end of the spool even though you blow quite hard. This illustrates Bernoulli's principle.
12. Mix baking soda and vinegar together to produce some carbon dioxide. This is slightly heavier than ordinary air. Secure a jar of carbon dioxide and drop in a burning piece of paper. What happens? Why?

13. Place a cork on the surface of a container of water. Put an inverted glass over the cork and push down on the glass. Does any water enter the glass? How can you tell? Tip the glass and let some air out. What happens to the cork? Place a candle on the cork and light the candle. Follow the same procedure as above. What happens to the cork now?

14. To illustrate that air has weight, lay a thin slat (at least three feet long) on a table with one end extending over the edge. Strike this end with your foot. The other end of the slat goes upward because the air flows around it. Now place the slat in the same position and cover the part on the table with a newspaper (unfolded). Strike the slat again and explain what happens now.

15. Place a heaping teaspoonful of charcoal in a pyrex bottle. Cover the charcoal with hydrogen peroxide and cover the bottle with cardboard. After a few minutes, light a wood splint. Blow it out and lower the splint into the bottle. What happens? What do you think would happen if more than one-fifth of the atmosphere were made up of oxygen?

16. Use a thermometer to measure the temperature of the air in a room at the following levels: (1) within an inch of the floor, (2) about five feet above the floor, and (3) very near the ceiling. Note any differences in the readings and explain.

17. Open a bottle of hydrogen sulfide and permit it to stand in a closed room for a few minutes. Discuss any observations in terms of diffusion.

18. Arrange a demonstration from a college or university to show the properties of liquid air.

19. Prepare some sulfur dioxide by burning a little sulfur in the bottom of an evaporating dish. Note the odor of this gas. Discuss the problems associated with sulfur dioxide as a pollutant in the atmosphere.

20. Prepare some hydrogen sulfide gas in the laboratory by reacting hydrochloric acid with ferrous sulfide. Cautiously smell the gas. Discuss the role of hydrogen sulfide in smog formation.

21. Construct a "mini-greenhouse" by inverting a large plastic bag over a potted plant, such as a geranium. A wire coat hanger should be bent to hold the plastic away from the plant. Introduce car exhaust fumes through a hose into the plastic bag. Run the motor long enough to force the good air from the bag. Remove the hose and secure the bag tightly to the flowerpot. Place the plant in the sunshine and refumigate several times a day. Do the same thing with another plant, but do not introduce any car exhaust into the control. After several days, compare the two plants.

22. Use a Ringlemann smoke chart to measure smoke density from a smokestack at half-minute intervals for one hour. The Power's Microringlemann chart (held at arm's length) or a full-size chart (at fifty feet) allows you to match the color of the smoke with known values of gray to black on the chart. Instructions for computing the percentage of smoke density, using simple mathematics, accompany the chart. The Microringlemann chart is

available from the National Coal Association, 1130 Seventeenth Street, N. W., Washington, D. C. 20036. The full-size chart is in Information Circular 8333. The Ringlemann smoke chart is available from the Bureau of Mines, U. S. Department of the Interior, Washington, D. C.

B. Field trips.
   1. To Seward, Pennsylvania, to see air pollution control devices of the Pennsylvania Electric Company's power station.
   2. To an industrial city to see air pollution problems of heavy industry.
   3. To Bethlehem Steel's Cambria slope mine cleaning plant to see air pollution and dust control methods.
   4. To a coke oven to observe the effect of fumes on vegetation, paint, etc.
   5. To a weather station.
   6. To an airport to note the dependence upon weather data and clear visibility.

C. Discussion.
   1. What causes impure air?
   2. Does air pollution have to accompany technical and industrial progress? Why or why not?
   3. Should all private industry be forced to adopt devices to prevent air pollution? Why or why not?
   4. Debate: The federal government is the only institution which can effectively deal with air pollution.
   5. Discuss the increase of automobile exhaust as a source of air pollution.
   6. Is it possible for a homeowner to fire a coal furnace without producing any smoke?
   7. Why do fish in an aquarium sometimes come to the top of the water?
   8. What are the common causes of air pollution?
   9. What can you do to prevent air pollution?
   10. What pollutants are present in the fumes of an automobile's exhaust? A diesel's exhaust? Which one causes the most air pollution? Why?
   11. Compare the advantages and disadvantages of aneroid and mercurial barometers.
   12. Explain how air pressure is used to fill a fountain pen. Why does a half-filled pen sometimes leak if carried in an airplane, while a full pen does not?
   13. Why does the air smell fresh and clean after a rain?

D. Bulletin board displays.
   1. Prepare graphic representations of air pollutants in relation to population density.
   2. Prepare a graph to show costs of air pollution.
   3. Show the symptoms and causes of air pollution. (Use pictures from magazines.)
   4. Prepare a map to show the wind zones of the world and how pollutants are dissipated.

5. Illustrate temperature inversion by drawings.
6. Obtain weather bureau maps to show high and low pressure areas.

E. Student activities and projects.

1. Make maps to show major air pollution areas in the United States and in the world. Write a paper explaining the causes of the pollution and what might be done to reduce it.
2. Write a paper on the "greenhouse effect" in relation to excessive carbon dioxide and what might result from such a phenomena.
3. Make a survey of causes and remedies of air pollution in your own area.
4. Remove the cap from a bottle of carbonated beverage and permit the contents to stand for a few days. Then taste the beverage and discuss why the beverage has a "flat" taste.
5. Record atmospheric pressure twice daily for a period of two weeks. Correlate weather conditions with the barometric readings.
6. Make and record periodic pollen counts throughout the season.
7. Construct a mural depicting how man has progressed in exploring the oceans of air, water, and space. How have the problems of oxygen, temperature, and pressure been solved?
8. Cover several panes of glass with a thin coating of vaseline and place in different locations around the home and school. Leave the glass for a varying number of days and compare the amount and type of residue trapped by the vaseline. Observe the wind direction. Examine the particles collected and try to identify the sources.
9. Check with the city or state air pollution commission to learn what laws have been made. Why were these laws enacted?
10. Observe an industrial smokestack. What kind of business is conducted in the building? Does it have a special device to reduce pollution? Can useful by-products be manufactured from the effluent?
11. What kind of heating fuel does your school use? Does it contribute to air pollution? What can be done to reduce the pollution caused by the school's heating system?
12. Check the family car, lawn mower, etc. Look at the color of the exhaust. Is it contributing to air pollution? Would pollution be reduced if it was properly tuned? Would this save you money?
13. Place a clean bucket out in a rainstorm at least six feet above the ground and away from any trees, buildings, etc. Examine the particulate with a magnifying glass or microscope. Where did the solid particles come from?
14. Construct an air filtering device to check air pollutants. Cut a two-inch hole in each end of a can. Place a piece of filter paper over one of the holes and cover this with plastic that has a two-inch hole coinciding with the hole in the can. Place a vacuum cleaner hose in the hole at the other end of the can. Draw the air through the filter paper and into the vacuum cleaner. Examine and identify the material filtered from the air.

II. Learning Materials

A. Audio-visual materials.

1. See list of sources at the end of the guide.

B. Books and pamphlets.

1. The Audubon Nature Encyclopedia, Vol. 1, Curtic Books (a division of the Curtis Publishing Company, Philadelphia, Pennsylvania, 1965.
2. Aylesworth, Thomas G., Our Polluted World, Applied Ecology of Air and Water, American Education Publications, Inc., Middletown, Connecticut, 1965.
3. Bagdikian, Ben H., "Death in Our Air", Saturday Evening Post, pp. 31-35, 106-110, October 8, 1966.
4. Berland, Theodore, "Our Dirty Sky", Today's Health, Vol. 44, No. 3, pp. 40-45, March, 1966.
5. Brmeazio, P. J. and Cameron, A. G. (editor), The Origin and Evolution of Atmospheres and Oceans, J. Wiley & Sons, New York, 1964.
6. Brower, Brock, "The Dark Satanic Breeze", Holiday, Vol. 40, No. 3, pp. 32-47, September, 1966.
7. Carr, Donald E., The Breath of Life, W. W. Norton, 1965.
8. Cole, Lamont C., "Can the World Be Saved", The New York Times Magazine, March 31, 1968.
9. "Ecology--Menace in the Skies", Time, Vol. 89, No. 4, pp. 48-52, January 27, 1968.
10. Edekon, Edward, "Battle for Clean Air", New York Public Affairs Commission, P. A. Pamphlet No. 403, 1967.
11. Faltermayer, Edmund, "We Can Afford Clean Air", Fortune Magazine, November, 1965.
12. "Fighting Auto Fumes--The Latest Prescription", U. S. News and World Report, Vol. LXII, No. 18, pp. 64-65, October 30, 1967.
13. Gamow, George, Matter, Earth, and Sky, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1962.
14. Herber, Lewis, Crisis in Our Cities, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1965.
15. Herfindahl, O. C. and Kneese, A. V., Quality of the Environment, Chapter IV, "Air Pollution", The Johns Hopkins Press, 1965.
16. Hout, Joseph Bixby, Man and the Earth, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, 1967.
17. Lewis, Alfred, Clean the Air, McGraw-Hill Book Company, New York, 1965.
18. Lewis, Howard R., "With Every Breath You Take", Reader's Digest, pp. 63, 68, 223, 232, September, 1965.
19. Lyn, Yolande, Experiments for the Science Classroom - Based on Air Pollution Problems, Bureau of Air Sanitation, State of California, Department of Public Health, (revised edition), 1962.

20. Mason, B., Principles of Geochemistry, Chapter 8, "The Atmosphere", pp. 208-222, 3rd Edition, J. Wiley & Sons, 1966.
21. Marquis, Ralph, Environmental Improvement (Air, Water, and Soil), The Graduate School, U. S. Department of Agriculture, 1966.
22. "The Menace in Our Dirty Air", Senior Scholastic, Vol. 90, No. 7, pp. 4-11, March 17, 1967.
23. Morholt, Brandwein, and Joseph, A Sourcebook for the Biological Sciences, Harcourt, Brace & Company, 1958.
24. Orday, S., Resources and the American Dream, Ronald Press, New York, 1953.
25. Parker, Bertha Morris, Science Experiences, Row Peterson & Company, Evanston, Illinois, 1959.
26. Partridge, J. A., Natural Science Through the Seasons, MacMillan Company, Inc., 2nd Edition, New York, 1958.
27. Perry, John, Our Polluted World, Franklin Watts, Inc., New York, 1967.
28. Petterssen, Sverre, Introduction to Meteorology, McGraw-Hill Book Company, Inc., 2nd Edition, New York, 1958.
29. Ramsey, William R. and Burckley, R. A., Modern Earth Science, Holt, Rinehart & Winston, Inc., New York, New York, 1961.
30. Rubey, W. W., "Model for the Evolution of the Atmosphere", Geological Society of America, Buddington Volume, p. 447, 1962.
31. Soporowski, Joseph, Air Pollution Experiments, High School Edition, Cooperative Extension Service, Rutgers University, New Brunswick, New Jersey, 1967.
32. Storer, John, Web of Life, Deain-Adair Company, New York, 1953, or New American Library of World Literature (a Signet Key Book), 1956.
33. Thompson, Phillip D., O'Brien, Robert, and the Editors of Life, Weather, Life Science Library, Time, Inc., New York, 1965.
34. "$300 Billion for Clean Air and Water", U. S. News and World Report, Vol. LXII, No. 14, pp. 42-45, April 3, 1967.
35. Trewartha, Glenn T., An Introduction to Climate, McGraw-Hill Book Company, Inc., 3rd Edition, New York, 1954.
36. Tufty, Barbara, "Poison Gas of Peace", Science News Letter, Vol. 88, No. 17, pp. 262, 269, October 23, 1965.
37. UNESCO Sourcebook for Science Teaching, UNESCO (printed in the Netherlands), 1956.

PLANTS

BACKGROUND INFORMATION

Man depends upon plant products for food, the clothes he wears, fuels to warm his home and operate his industries, lumber to build homes, and vitamins to maintain health.

Plants are important to all living things because of their ability to produce food. The leaf of a green plant is a chemical laboratory that carries on an interesting and unique reaction which is of vital importance to all forms of life. It is here that all of our food has its origin.

Botanists refer to this process as photosynthesis and represent it by the following equation:

$$12H_2O + 6CO_2 \xleftrightarrow{\overset{\text{Light Energy}}{\downarrow}} C_6H_{12}O_6 + 6O_2 + 6H_2O$$

or

$$\text{Water} + \text{Carbon Dioxide} \longleftrightarrow \text{Glucose} + \text{Oxygen} + \text{Water}$$

This is an oversimplification of the actual process, but it does represent the raw materials and the end products of this process. Energy from the sun is utilized in converting water from the soil and carbon dioxide from the air into sugar and oxygen, both of which are essential for all living organisms. This is the basic part of the oxygen cycle which helps to maintain the oxygen content of the atmosphere. The food energy which is present in the sugar molecule is the energy from the sun which was trapped by the chlorophyll and transferred by it to the sugar molecules.

The sugar manufactured by a green plant may be used directly by the plant as a source of energy (respiration), or it may be converted (by chemosynthesis) into starch, fats, or (with the addition of certain minerals from the soil) proteins. Fats, proteins, and carbohydrates are the foods of the plant. They may be used as a source of energy or may be further altered and combined to form the thousands of organic compounds found in plants.

There are many controlling factors related to photosynthesis. The principle of limiting factors states that the rate at which a process proceeds depends upon the factor that is limiting. In other words, a chain is no stronger than its weakest link. Light is a major limiting factor in photosynthesis. Under natural conditions, photosynthesis is at a maximum at one-tenth the full intensity of sunlight. Color also affects photosynthesis--blue and red being the most strongly absorbed. Carbon dioxide concentration, water supply, the amount of chlorophyll, and the temperature all affect the kinetics of photosynthetic reactions.

Plants represent the major source of food used by animals. Herbivores feed exclusively on plants and are primary consumers. Carnivores feed on herbivores or other carnivores and are secondary or tertiary consumers. Ominvores feed on plants or herbivores. This is the basis of the biological generalization known as the "food chain".

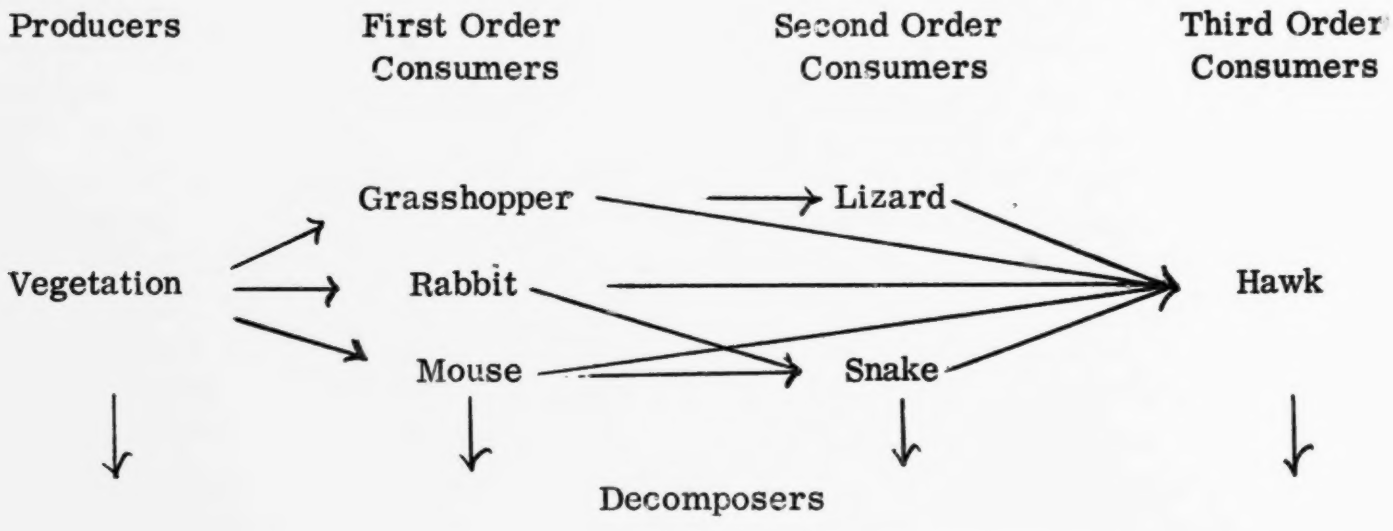
All food chains start with a green plant, a producer organism, and end when the organic matter thus created has been broken down by consumer organisms (animals and bacteria) into its component parts and returned to the soil.

Lengths of food chains vary from several relationships to many relationships. In any event, the total amount of energy stored in the organic matter of a food chain becomes less and less the further removed it is from the green plant which produced it. In other words, a blade of grass is more efficient in converting the energy of the sun into food than an animal that eats the grass. The further removed from the food producer, the less efficient is the organism in releasing and utilizing the energy found in the food chain. For example, a man would have to eat much more meat than wheat to obtain the same energy equivalent. The food chain is ended when the organic material produced by the plant from raw materials and energy from the sun is reduced to water, gas, and inorganic minerals.

A food chain is a diagram of a single energy pathway between specific organisms and can be illustrated as follows:

Grass ⟶ Rabbit ⟶ Hawk

However, relationships in nature are not usually this simple, and energy pathways must be shown by a food web. This shows the relationship of all plants and animals in an area. The following is an example of a food web:



There is little possibility that we can free ourselves from dependence upon plants in the future. If atomic and solar energy becomes widely available, we would at best be freed from dependence upon plants from the past in the form of coal, oil, and natural gas. It seems probable that the fundamental source of energy for all living things will be green plants for many years to come.

There are ninety-two elements that occur in the crust of the earth. Of these ninety-two elements, twenty to twenty-five are essential constituents of living organisms. A few of these are so abundant and so well distributed that we need give them no concern, but others may at times be subject to local shortages. As a result, plant growth is often limited because of a shortage of one or more of these essential elements. In some cases, the available supply of some essential elements (N, P, K) may already be in use in a living organism and thus be unavailable for other plant use. Before it can be used again, it must be released in the soil. When plants die, bacteria and other fungi feed upon the dead organic matter and break it down into the component parts from which it was originally constructed. These nutrients then are thus released into the soil again for reuse. The elements present in living tissues are constantly in circulation passing from one organism to another and back to the soil in endless cycles. This is referred to as the organic cycle. It is easier to understand this cycle if it is broken down into its sub-cycles, such as the nitrogen, carbon, and oxygen cycles.

Within the American economy, twenty billion dollars worth of raw materials are accounted for under the heading of agriculture. Food is by far the largest single item in the American family budget, taking somewhat over a fifth of all consumer expenditures. The task of keeping people fed involves about 15% of the productive activity of the United States economy.

A typical plant is made up of four organs--root, stem, leaf, and flower.

The root, in general, is that portion of the plant which is underground. The primary roots grow directly from the root portion of the embryo while the secondary roots are branches of the primary roots. Adventitious roots develop from the stems or leaves of the plants.

In the tap root system, there is one main root, the tap root, which frequently penetrates deeply into the soil; numerous smaller secondary roots branching from the tap root ramify throughout the soil. The carrot is a typical example. This type of root system is frequently able to withstand drought conditions but is of little value in preventing soil erosion.

The fibrous root system, present in all members of the grass family, has numerous main roots all about the same size. These roots usually ramify in all directions in the upper layer of soil but do not penetrate to a great depth. This type of root system is of great value in preventing soil erosion but does not insure a drought resistant plant.

The secondary roots in both types of root systems branch repeatedly, ending in thousands of root tips, each of which has hundreds of microscopic root hairs. Although small, the aggregate root hairs represent a large surface area which is responsible for the absorption of the water and dissolved minerals needed by the plant.

Diffusion and osmosis are important processes in root physiology. The tendency of molecules to mix in space is known as diffusion. The molecules diffuse from a region of greater concentration into a region of lesser concentration. Osmosis is a special type of diffusion and usually refers to the diffusion of water through a semi- (selective) permeable membrane. As water diffuses into roots, it builds up a pressure called osmotic pressure, which causes the root to possess a stiffness called turgor. The turgor in root cells creates a root pressure which is often great enough to force water through the stem and out through the leaves of the plant. If osmosis occurs in reverse manner and water leaves the cells, plasmolysis occurs resulting in a loss of turgor.

The automatic response of a part of a plant or the entire plant toward or away from a stimulus is called a tropism. The prefix describes the stimulus and a negative tropism indicates movement away from the stimulus. Thus, geotropism is attraction toward gravity while negative phototropism is a response away from light.

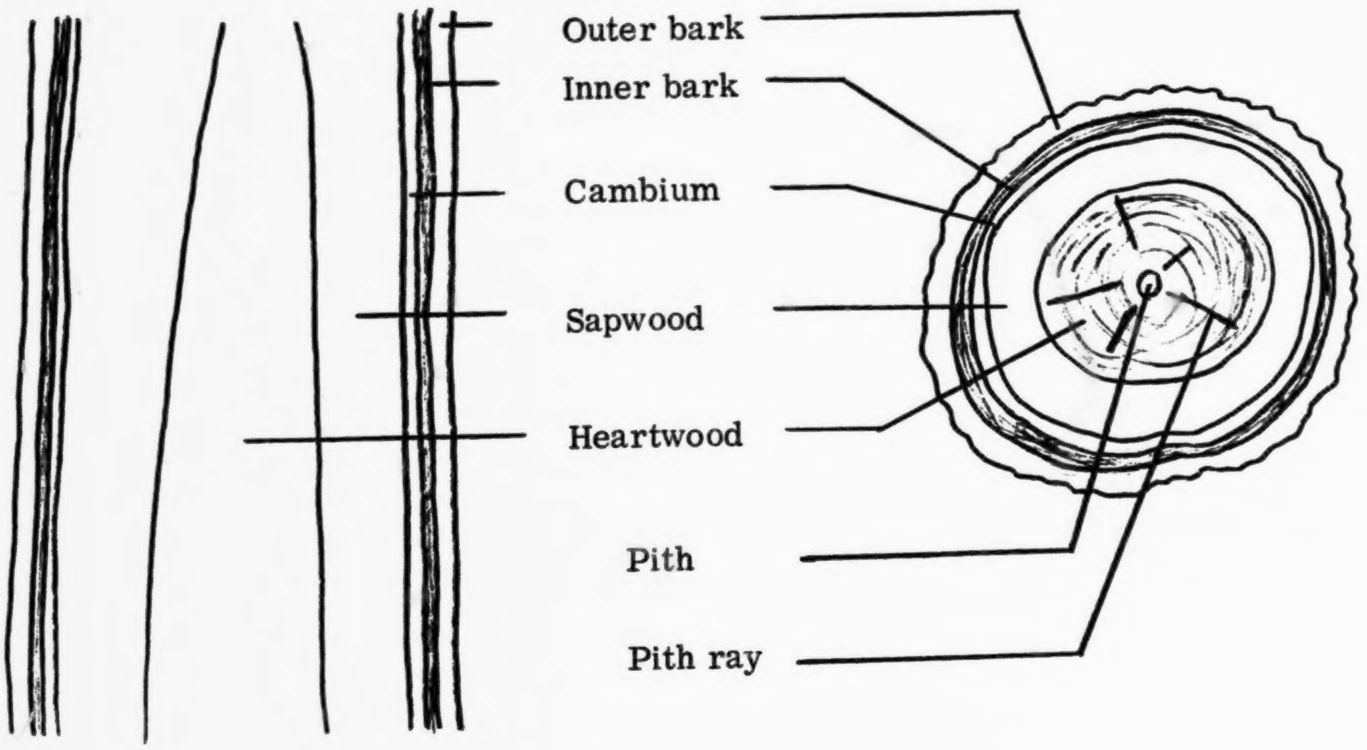
Woody stems are perennial and grow in length, increase in diameter, and form branches season after season. The pith is the centermost part of a woody stem. The wood (xylem) is made up of concentric layers of wood known as the annual rings. An annual ring represents the wood produced during a growing season and may be used to approximate the age of the tree. In older trees, the outermost annual rings are usually lighter in color, not as hard, and make up the sapwood. The sapwood conducts water and minerals from the roots to the leaves. The innermost portion of the trunk is generally deadwood (heartwood) and serves primarily as support for the tree.

Surrounding the outside of the trunk is the bark of the tree. This consists of the outer bark or cork which is a protective layer and the inner bark or phloem which conducts food from one part of the plant to another. The actively growing part of the trunk, the cambium, is located between the phloem and the sapwood and produces new xylem cells on the inner surface and phloem cells on the outer surface.

The rays radiate outward from the center of the stem and conduct food from the phloem into the xylem and pith of the stem.

Herbaceous stems have much less woody tissue than woody stems. A ring of vascular bundles, each consisting of phloem fibers, phloem, and xylem, surrounds the stem about halfway between the epidermis on the outside and the hollow center in the inside. (Note: Not all herbaceous stems are hollow.)

DIAGRAM OF A WOODY STEM

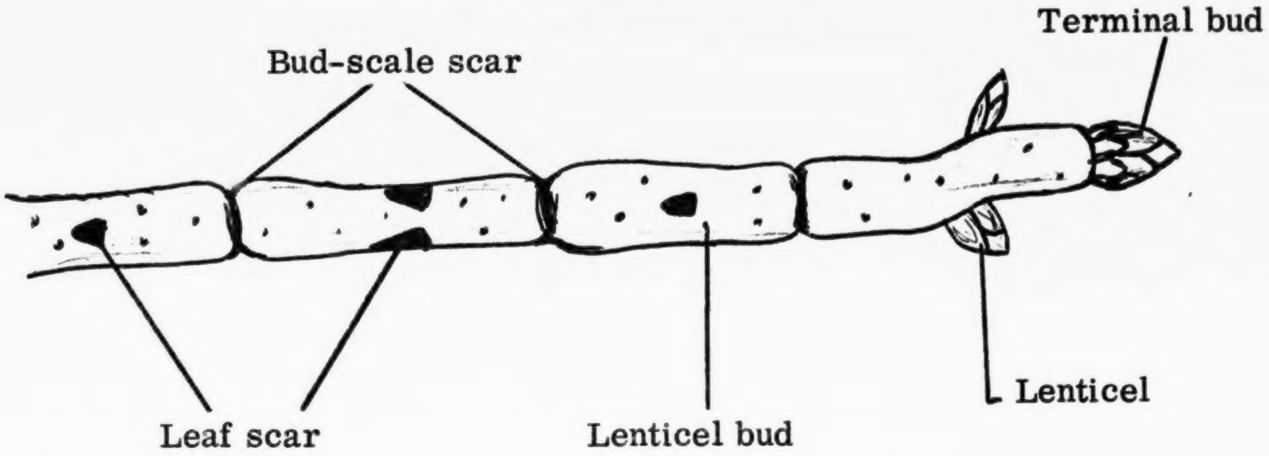

Outer bark
Inner bark
Cambium
Sapwood
Heartwood
Pith
Pith ray

Longitudinal Section

Cross Section

The stem of the monocot consists of the epidermis and the pith. Embedded in the pith at random, but usually more abundant around the outside, are numerous vascular bundles containing xylem and phloem. These bundles are not arranged in a distinct ring as they are with herbaceous stems.

The drawing on the following page indicates the external parts of a woody stem from a decidious plant.



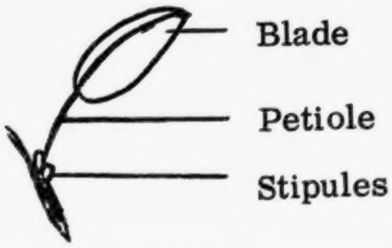
A bud is a miniature shoot, consisting of a short length of stem, tiny leaves, and (sometimes) flowers. The bud may or may not have modified leaves called protective scales. When growth is resumed, the scales drop off and leave scars. The bud-scale scar indicates where growth started and ended for a growing season. Growth from a terminal bud increases length, and growth from a lateral bud produces a new branch. Lenticels are openings in the bark through which gases diffuse. A leaf scar is formed when the leaf falls from the branch and indicates where a leaf once grew.

The blade of a leaf is a thin structure in which most of the photosynthesis takes place. The petiole is the stalk of the leaf, and the stipules are small, paired structures at its base. If the petiole is absent, the leaf is said to be sessile. The arrangement of leaves on a stem or branch is termed phyllotaxy. If only one leaf appears at a node, the phyllotaxy is said to be spiral or alternate; if two arise at a node, it is opposite; and if three or more arise, the arrangement is whorled.

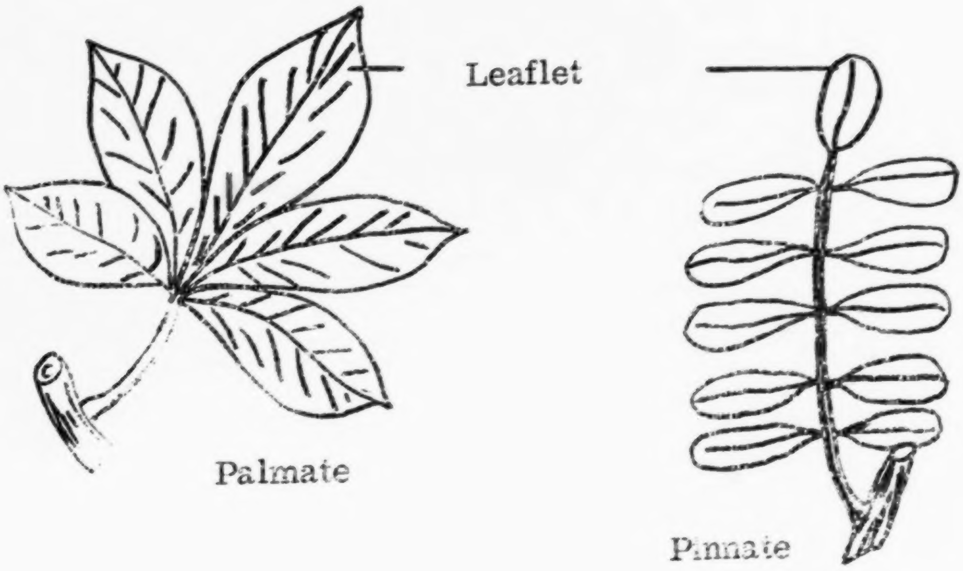
The arrangement of veins through the leaf blade is termed venation. In palmate venation, the veins branch out from the tip of the petiole. In pinnate venation, a midrib extends through the center of the blade from which small veins branch and run to the margin of the leaf. In parallel venation, the veins run parallel from the base of the leaf to the tip.

If the blade of a leaf is one piece, it is called a simple leaf. If the blade is divided into three or more parts, it is called compound; and each separate part is called a leaflet. When the leaflets arise from a common point, the leaf is palmately compound; and when they are arranged opposite each other, the leaf is pinnately compound.

The upper epidermis, usually with a clear, waxy covering called the cuticle, is a clear layer of cells. Its major function is protection. The mesophyll or inner portion of the leaf consists of two layers, the top or palisade layer and the spongy layer. The spongy layer


Blade
Petiole
Stipules

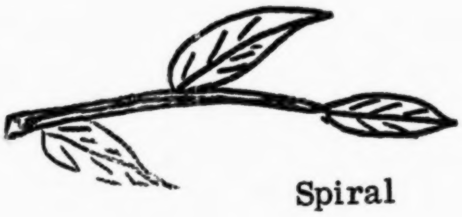
SIMPLE LEAF



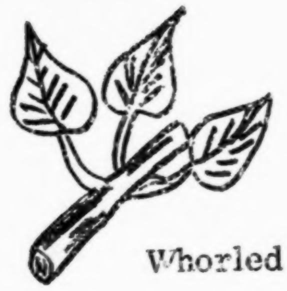
Palmate

Pinnate

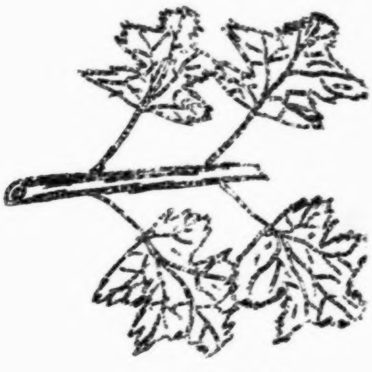
COMPOUND LEAF



Spiral

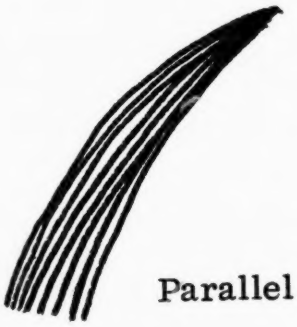


Whorled

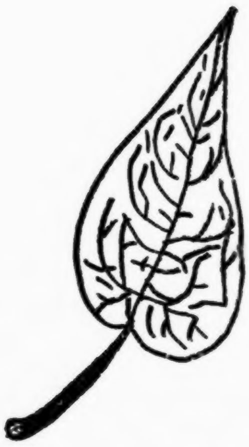


Opposite

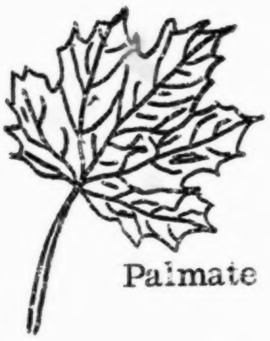
PHYLLOTAXY



Parallel



Pinnate



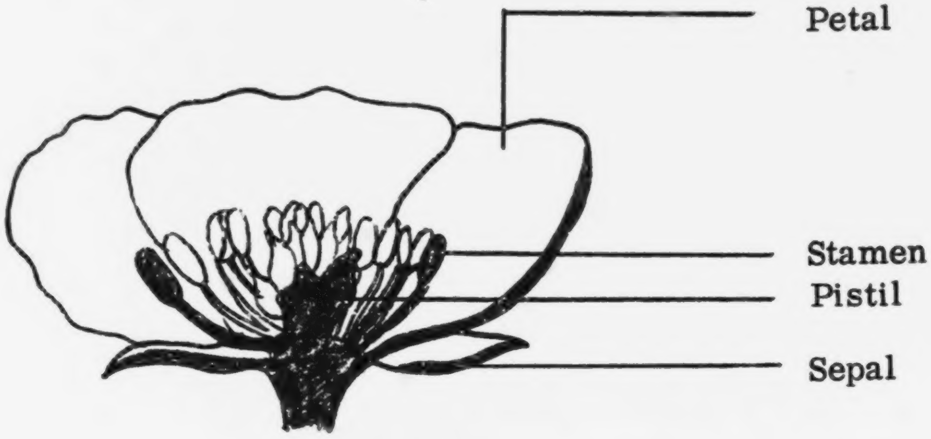
Palmate

VENATION

has many intercellular spaces and contains the majority of the chloroplasts which contain the chlorophyll. It is in this layer that photosynthesis occurs. The lower epidermis contains many pores (stomates) that allow gases to enter and leave the leaf. Each pore is surrounded by two bean-shaped cells known as guard cells. These guard cells regulate the opening and closing of the stomate and thereby regulate moisture and gas content in the leaf.

A flower grows from a special flower stalk, the end or tip of which is the receptacle. The outer ring of floral parts consists of several green leaflike structures called sepals (collectively called the calyx). Inside the calyx is the corolla which consists usually of one or more rows of petals. Since these structures are not directly involved in reproduction, they are called non-essential parts.

DIAGRAM OF FLOWER STRUCTURE (BUTTERCUP)



Pollination involves the transfer of pollen from an anther to a stigma with the sperm nucleus of the pollen traveling through the style and into the ovary, there uniting with the ovum. Self-pollination involves the transfer of pollen from the anther to a pistil of the same flower or to another flower on the same plant.

Cross-pollination involves a transfer of pollen from an anther to a pistil of a flower on another plant. Both wind and insects aid in the cross-pollination process.

A fruit is a ripened ovary containing seeds. Any plant structure containing seeds is a fruit, even though the grocery store may classify it as a vegetable. In the mature fruit, the part derived from the ovary wall is called the pericarp. Fruits are classified principally on the basis of the number of ovaries involved in their formation and on the nature of the pericarp. A simple fruit is produced from a flower that has a single pistil and, therefore, only one ovary. Simple fruits can be further sub-divided into berries, drupes, and pomes. In the berry, the entire ovary wall is fleshy; the drupe fruit has an outer fleshy layer and a hard inner layer (stone); the pome is a fruit with a core. Aggregate fruits consist of several ripened ovaries of a flower with many pistils. Multiple fruits are produced when the ovaries of several flowers grow together.

Fruits are also classified as fleshy and dry. Fleshy fruits include the apple, pear, and bananna; dry fruits include the acorn and hickory nuts. Dry fruits are sub-divided into dehiscent and indehiscent. Dehiscent fruits split along definite seams when ripe and liberate the enclosed seeds while indehiscent fruits do not open along definite seams when ripe, but the seeds eventually rupture the ovary walls.

A seed is a matured ovule. Each seed contains the embryo (a tiny living plant), stored food, and the seed coat. Food is sometimes stored in thick seed leaves called cotyledons. Monocots have one cotyledon while dicots have two.

Plants may be classified according to their life cycle. If a plant completes its life cycle in one year, it is an annual. A biennial takes two years, and a perennial is a plant that lives longer than two years. They may blossom yearly (fruit trees) or may blossom only once and then die.

Scientists classify organisms into large groups based on similarities and sub-divide these into smaller groups based on differences. Minute saprophytic, parasitic one-celled organisms, are referred to as bacteria. They are found in one of three general forms: coccus, ball-shaped; bacillus, rod-shaped; and spirilla, corkscrew-shaped. In general bacteria are beneficial because they increase the fertility of the soil, decompose dead matter, are used in certain food industries and certain industrial processes, and in making antibiotics. Some are harmful due to disease-causing ability in living organisms.

Simple green plants lacking stems, leaves, roots, and flowers are classified as algae. Algae represent an important "link" in aquatic food chains. In fact, most seafood can be traced back to algae.

Fungi are simple plants lacking stems, leaves, roots, and flowers. They differ from algae in that the fungi do not contain chlorophyll. They may be beneficial because they produce food (mushrooms), increase soil fertility by decomposing dead organic matter, are used in industrial processes (yeast), and produce medicine (penicillin).

Mosses and liverworts possess simple stems and small leaves. Instead of roots, they have root-like structures called rhizoids. They never grow more than two or three inches high because their stems do not contain any woody tissue. The Bryophytes contain chlorophyll and are therefore capable of producing their own food. Mosses are of some economic value to man. The most important kind is peat moss or sphagnum. Peat can be added to the soil to help retain moisture and is also dried and used as fuel in some countries. No economic importance is attached to liverworts.

Green plants having true roots, stems, and leaves, but no flowers are classified as ferns. Ferns helped to form our present-day coal deposits and also help to prevent soil erosion.

Seed plants have true roots, stems, leaves, and produce seeds. They are subdivided into gymnosperms and angiosperms. All gymnosperms are woody and most of them are cone-bearing plants. This includes the pines, spruces, firs, hemlocks, etc. all of which are important because of their production of softwoods in the lumber industry and for ornamental uses.

The angiosperms are the flowering plants and include the subdivisions of monocotyledons and dicotyledons. The monocots are plants having the floral parts in three's, parallel venation, and a single cotyledon in the seed. Grasses represent the most important family of the monocots. They are man's chief source of food (wheat, rice, corn, oats, etc.).

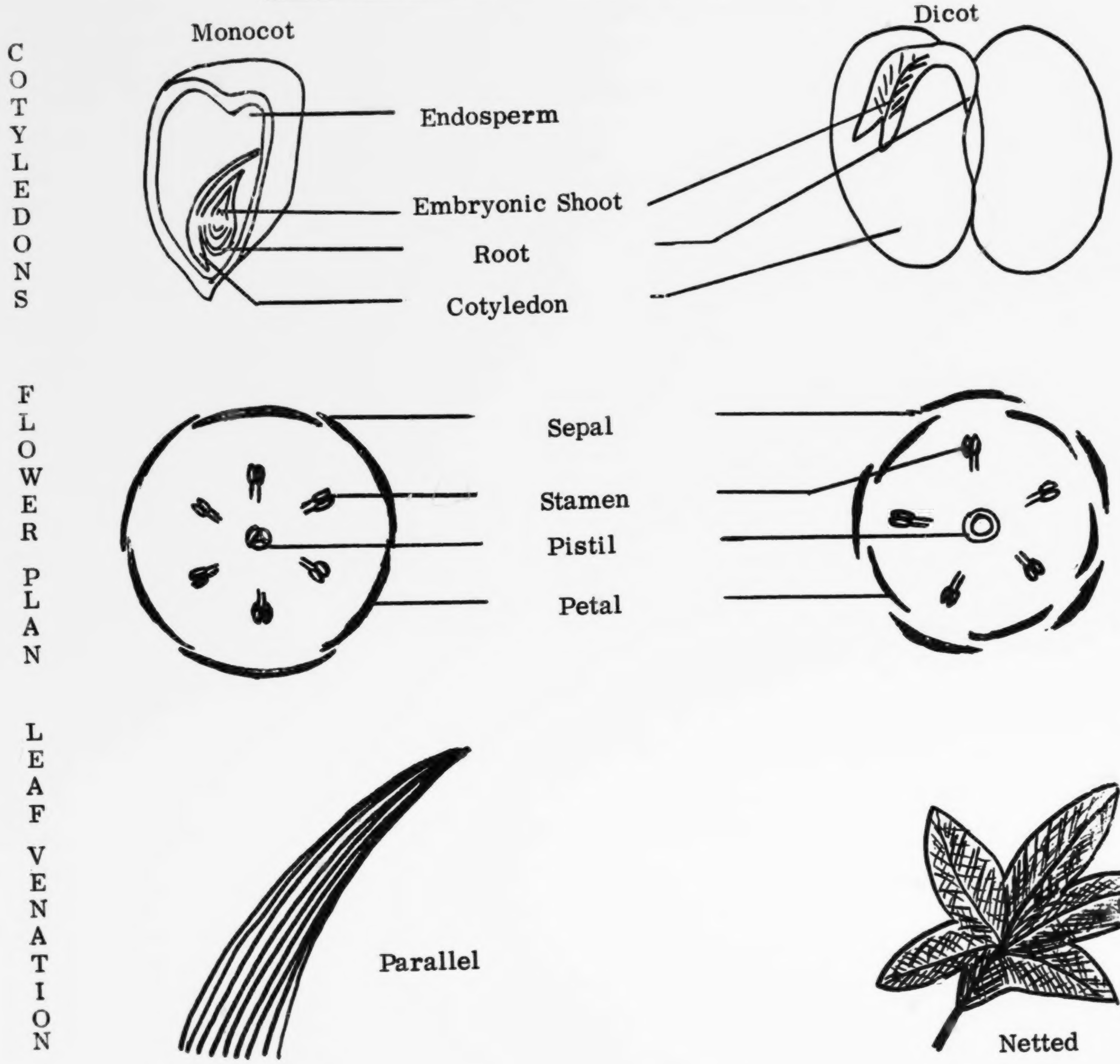
Dicots have the floral parts in four's or five's, net venation, and two cotyledons in the seeds. Many of the trees (hardwoods), most of the garden crops, weeds, and flowers are representatives of this group (see diagram on page H-11).

There are approximately 280 different kinds of trees and shrubs native to Pennsylvania. Of this number, 110 are usually classified as trees.

Pennsylvania means Penn's woods. It derived its name from its founder and the dense and extensive forest growth which covered the state. The original forest covered almost the entire area of the state which is usually given as 29,692,480 acres. Today, approximately fifty per cent of the state is covered with forest, and much of this is unproductive.

Seventy-six per cent of the privately owned forest land of the nation is in 4,210,000 woodland plots averaging sixty-two acres each. If our nation is to achieve maximum forest benefits, it is obvious that these private owners must practice good forestry. Most of these woodlots are located on marginal farmland; are composed of second growth timber; contain many weed trees, wolf trees, deformed trees, etc; and are not protected from fire, insects, or disease.

COMPARISON OF MONOCOTS AND DICOTS


COTYLEDONS
Monocot
Dicot
Endosperm
Embryonic Shoot
Root
Cotyledon
FLOWER PLAN
Sepal
Stamen
Pistil
Petal
LEAF VENATION
Parallel
Netted

Originally the eastern one-third of the nation was heavily forested as was the Rocky Mountain area, the Sierras, and the Pacific Northwest. The early settlers used the trees for building homes, barns, boats, for fuel, for tan bark, and for shipment to Europe. Even so, the demand for cleared land for agriculture was so great that much valuable timber was burned just to clear the land for crops and grazing.

By the time the thirteen original colonies had won their independence, the lumbering industry was one of the chief industries of the nation and has remained so ever since. From New England, New York, and Pennsylvania, logging had reached Michigan by 1840. By 1900, most of the pine in the Great Lakes states had been removed to make way for farming. By the 1920's, the southern pine areas had been exploited along with the Pacific Coast and the Rocky Mountains. The Pacific Northwest is now being exploited in the same manner. Much of our forest reserves have been depleted by trespassing or manipulation of federal lands into the hands of private individuals.

During the early period of the lumber industry, the amount of waste was very high. Often only certain desirable species, such as white pine, were used; other species were destroyed. Of those species that were used, often only forty per cent or even less of a tree was utilized. Today, very few species are regarded as weed trees and as much as seventy-five per cent of a tree is utilized in one way or another. Fortunately, the forest industry itself is taking the initiative to stop waste and spoilage of the forest resources.

The first instances of preserving valuable stands of hardwoods came about as a result of British colonial policy. Hardwoods were needed to replace depleted timber supplies in England for the British Navy. Upon gaining independence, the United States also recognized this need of conserving timber for its Navy. Thus, the first glint of any conservation of plant life came out of nationalistic necessity. Not until the time of Gifford Pinchot did we develop any national attitude toward the conservation of timber. For the most part, timber was ruthlessly exploited. Tracts of timber were burned to make room for agricultural pursuits. Timber was America's chief building material and was used in mining, railroading, bridges, and even roads.

The history of the Great Plains and of the West shows an equal disregard for grasslands. Range country was overstocked and overgrazed. The gang plow sliced into soil and exposed it to erosion. Unwise farming practices resulted in dust storms in many areas west of the Mississippi River.

The United States government is the owner of millions of acres of timber and grasslands. However, many more millions of acres of timber and grassland are owned by private individuals. The various states are owners of vast plots within their own states. It is in the private domain that plant exploitation takes place at an accelerated rate. It is also in the private domain where conservation practices must be used and explained by educational programs, government aids, and regulations if we are to stop the massive waste of our natural resources.

One of the greatest dangers to plants in general and forests in particular is fire. Effective fire control presupposes initial planning on the part of the foresters, availability of equipment, and trained fire fighters to supervise the work of putting out the fire. Early detection of the fire is important. Fire towers should be manned during the fire season.

A fire requires oxygen, fuel, and a high temperature in order to continue to burn. Fire fighting consists of eliminating one or more of these requirements. This can be accomplished by use of fire lanes, backfire, water, or smothering the fire.

However, the best method of fighting fire is prevention. This may be accomplished by educational programs, regulation of hunting and fishing, construction of fire lanes, and proper care of the forest area.

The damage done by a fire includes loss of timber, present and future; soil fertility is destroyed; erosion starts; floods occur; droughts and polluted streams are common; wildlife is destroyed; and recreational values are lost.

Green plants are most significant in their role as original producers of food. Thirty-three to forty per cent of the average American diet consists of livestock products and sixty to seventy per cent comes directly from crops, mostly small grains and potatoes. The chief food staple of over one-half the people on earth is rice; wheat and corn are the chief staples for all the remainder. In all cases, the food supply comes directly or indirectly from the plants.

Cotton is still the most important fiber in the world despite increasing use of modern synthetic fibers. Cellulose, obtained chiefly from cotton and wood, is used in making paper, cotton cloth, rayon fiber, explosives, plastics, cellophane, etc.

Hemp, jute, and flax are used in the manufacture of coarse fabrics, rugs, ropes, and twines. One of the first plant fibers to be woven was flax. It was cultivated in the Kurdish foothills of Iraq as early as 5000 B.C., and evidence indicates that it was grown in Ur (Mesopotamia) and the Lake Fayum region (Egypt) at the same time. It was replaced in the Near East about 1500 B.C. when cotton increased in importance. Flax and the vine grape were very important in Egyptian culture. Flax woven to linen was used to wrap mummies, for bed coverings, and general clothing. Wine was consumed at much the same rate as it is in France today and was necessary for religious functions. By 2000 B.C., taverns were an important part of Egyptian life and were freely located along the Nile River.

The use of plants for drugs is an ancient practice. Man has also used a number of plants for their stimulating or narcotic effect. These include coffee, tea, opium, heroin, cola seeds, coca leaves, marijuana, and tobacco. The hallucinatory effects of plants have long been known by North American Indians. The use of peyote by Indians of the Southwest eventually developed into a religious cult during the nineteenth century. Native South American Indians are frequently observed eating, chewing, and smoking various parts of the cocoa plant.

"Wonder drugs", such as penicillin, aureomycin, and streptomycin, are products of molds and are important in the control of specific bacterial and rickettsial diseases.

Plants are used for research because they can be grown in large numbers, and we have no compunction in destroying them in quantity if it is desirable for the purpose of research.

The recreational value of our nation's forested areas is well recognized, particularly in Pennsylvania. The beauty of plants has been responsible for a vast industry involving seeds men, horticulturalists, nurserymen, etc.

The fundamental interdependency between man and nature can be better understood by synchronizing the remains of carbonized wood, grains, and pollen to certain levels of cultural development. This field of research is called paleoethnobotany. The botanical materials are found as carbonized plant parts, imprints of grain and seeds, lignified vegetable material, such as food deposits in Egyptian tombs and the silica skeletons of chaff and straw. Occasionally, the stomach contents of prehistoric corpses preserved in peat bogs have revealed seeds and grain for analysis. Plants give us a clue to past peoples and climate. By studying them, it is possible to deduce the type of climate in prehistoric days and to follow the cultures and civilizations of early man.

Though most plants are beneficial to man, some are unpleasant, others harmful. The cost of weed control measures plus the reduction in productivity of crop plants due to weed competition is estimated to be five billion dollars per year. The United States Department of Agriculture estimates that the productive yield from 120 million acres never reaches the consumer due to losses from weeds, insects, and bacterial and fungal diseases.

Many people are allergic to plants, primarily poison ivy, poison oak, poison sumac, and ragweed. Serious diseases of man, such as typhoid, tuberculosis, and cholera are caused by bacteria while various species of fungi are responsible for a whole list of skin diseases, such as ringworm and athletes foot.

Our tremendous consumption of and dependence on the products of forests, field, grassland, and fossil fuels make these assemblages of plants our greatest natural resource. Unfortunately, the future of agriculture and the world's ever-increasing shortage of food depends as much upon socio-cultural phenomena and government policies in education, taxation, land reform, investment, etc. as it does on available technology.

The relationship of plant to soil is an intimate one since most of our useful plants grow in the thin, fertile soil of the earth's crust. Hence, good soil conservation practices which protect the soil also help conserve the plants. You cannot have one without the other. Food plant production is closely related to water conservation. Without an adequate supply of water, plants cannot grow; and without good plant coverage, water cannot be conserved.

OUTLINE OF CONTENT MATERIAL

- I. Importance of Plants
  - A. Photosynthesis.
    - 1. Sole source of food.
    - 2. Formula.
    - 3. Takes place in the leaf.
    - 4. Requirements of photosynthesis.
      - a. Water.
      - b. Carbon dioxide.
      - c. Chlorophyll.
      - d. Light.
    - 5. Limiting factors of photosynthesis.
      - a. Carbon dioxide intake.
      - b. Amount of water.
      - c. Amount of light.
      - d. Amount of chlorophyll.
  - B. Organic cycle.
    - 1. Nitrogen cycle.
    - 2. Carbon cycle.
    - 3. Oxygen-carbon dioxide cycle.
    - 4. Others.
  - C. Food chains and food webs.
  - D. Economy.

- II. Structure of Plants
  - A. Roots.
    - 1. Classification.
      - a. Primary.
      - b. Secondary.
      - c. Adventitious.
    - 2. Root systems.
      - a. Tap roots.
      - b. Fibrous.
    - 3. Various kinds of roots.
      - a. Fleshy (large tap roots).
      - b. Aerial (Spanish moss).
      - c. Brace (corn).
      - d. Aquatic (Cypress tree).
    - 4. General anatomy.
      - a. External.
        - 1. Epidermis.

            2. Root hairs.
            3. Root cap.
        b. Internal.
            1. Central cylinder.
            2. Cortex.
    5. Function of roots.
        a. Anchorage.
        b. Food storage.
        c. Reproduction.
        d. Absorption.
            1. Diffusion.
                a. Permeable membrane.
                b. Semi-permeable membrane
            2. Osmosis.
                a. Turgor.
                b. Root pressure.
                c. Plasmolysis.
    6. Reaction of roots to environment.
        a. Hydrotropism.
        b. Geotropism.
        c. Chemotropism.
        d. Negative phototropism.
B. Stems.
    1. Types.
        a. Herbaceous.
        b. Woody.
        c. Monocotyledons.
    2. Classification.
        a. Aerial.
            1. Shortened stem.
            2. Creeping stem.
            3. Climbing stem.
            4. Erect stem.
        b. Underground stems.
            1. Rhizomes.
            2. Corms.
            3. Tubers.
            4. Bulbs.
    3. General anatomy.
        a. Woody stem.
            1. Internal.
                a. Pith.

        b. Xylem.
          1. "Annual" rings.
          2. Heartwood.
          3. Sapwood.
        c. Cambium.
        d. Bark.
          1. Phloem.
          2. Cork.
        e. Rays.
      2. External.
        a. Buds.
          1. Terminal.
          2. Axillary.
        b. Leaf scar.
        c. Bud-scale scar.
        d. Lenticels.
        e. Node.
        f. Internode.
    b. Herbaceous stem.
      1. Epidermis.
      2. Cortex.
      3. Vascular bundle.
      4. Pith rays.
      5. Pith.
    c. Monocotyledonus (monocot) stem.
      1. Epidermis.
      2. Pith.
      3. Vascular bundle.
  4. Functions.
    a. Conduction.
    b. Storage.
    c. Support.
    d. Reproduction (asexual).
      1. Grafting.
      2. Budding.
C. Leaves.
  1. External features.
    a. Blade.
    b. Petiole.
    c. Stipules.
  2. Phyllotaxy.
    a. Alternate.

        - b. Opposite.
        - c. Whorled.
    - 3. Venation.
        - a. Palmate.
        - b. Pinnate.
        - c. Parallel.
    - 4. Leaf forms.
        - a. Simple.
        - b. Compound.
            - 1. Palmately compound.
            - 2. Pinnately compound.
    - 5. Internal anatomy.
        - a. Cuticle.
        - b. Upper epidermis.
        - c. Mesophyll.
            - 1. Palisade and spongy layers.
                - a. Chloroplasts.
                    - 1. Chlorophyll.
        - d. Lower epidermis.
            - 1. Stomata.
                - a. Guard cells.
    - 6. Function of leaves.
        - a. Photosynthesis.
        - b. Transpiration.
        - c. Guttation.
        - d. Storage.
        - e. Reproduction.
- D. Flower.
    - 1. General anatomy.
        - a. Essential parts.
            - 1. Stamen.
                - a. Filament.
                - b. Anther.
            - 2. Pistil.
                - a. Stigma.
                - b. Style.
                - c. Ovary.
        - b. Non-essential parts.
            - 1. Receptacle.
            - 2. Sepals (calyx).
            - 3. Petals (corolla).
    - 2. Types of flowers.
        - a. Complete.

        - b. Incomplete.
    - 3. Function of flowers.
        - a. Reproduction (sexual).
            - 1. Self-pollination.
            - 2. Cross-pollination.
- E. Fruits.
    - 1. Types of fruit.
        - a. Simple fruits.
            - 1. Fleshy pericarp.
                - a. Berry.
                - b. Drupe.
                - c. Pome.
            - 2. Dry pericarp.
                - a. Dehiscent.
                - b. Indehiscent.
        - b. Aggregate fruits.
        - c. Multiple fruits.
    - 2. General anatomy.
    - 3. Function of fruits.
        - a. Protection of seeds.
            - 1. Water loss.
            - 2. Insects.
            - 3. Disease.
        - b. Seed dispersion.
- F. Seeds.
    - 1. General types.
        - a. Monocots.
        - b. Dicots.
        - c. Polycots (gymnosperms).
    - 2. General structure.
        - a. Internal structure of the seed.
            - 1. Endosperm.
            - 2. Embryo.
                - a. Cotyledons.
                - b. Hypocotyl.
                - c. Plumule (epicotyl).
                - d. Radicle.
        - b. External.
            - 1. Seed coat (testa).
            - 2. Hilum.
            - 3. Micropyle.
    - 3. Uses.
        - a. Germination.

            - 1. Moisture.
            - 2. Temperature.
            - 3. Oxygen.
        - b. Foods.
            - 1. Cereals.
                - a. Wheat.
                - b. Corn.
                - c. Rice.
                - d. Oats.
                - e. Barley.
                - f. Rye.
            - 2. Legume fruits.
                - a. Beans.
                - b. Peas.
                - c. Soybeans.
                - d. Peanuts.
            - 3. Others.
    - 4. Dormancy in seeds.
    - 5. Viability.
    - 6. Effects of radiation.

III. Classification of Plants

- A. By life cycle.
    - 1. Annual.
    - 2. Biennial.
    - 3. Perennial.
- B. Scientific classification.
    - 1. Bacteria.
        - a. General groups.
        - b. Forms.
            - 1. Coccus.
            - 2. Bacillus.
            - 3. Spirillum.
    - 2. Algae.
    - 3. Fungi.
    - 4. Mosses.
    - 5. Ferns.
    - 6. Seed plants.
        - a. Gymnosperms.
        - b. Angiosperms.
            - 1. Monocotyledons.
            - 2. Dicotyledons.

IV. Plant Growth
- A. Factors influencing plant growth.
  - 1. Water.
  - 2. Temperature.
  - 3. Topography.
  - 4. Wind.
  - 5. Other plants.
    - a. Parasites.
    - b. Saprophytes.
    - c. Competition.
  - 6. Depth of water table.
  - 7. Animals.
    - a. Insects.
    - b. Rodents.
    - c. Grazing animals.
    - d. Man.
  - 8. Soil.
    - a. Amount of humus.
    - b. Kinds and amounts of minerals present.
    - c. Soil pH.
    - d. Soil type.
  - 9. Fire.
- B. Where plants grow.
  - 1. Plant formations.
    - a. Forests.
    - b. Grasslands.
    - c. Chaparral.
    - d. Deserts.
    - e. Tundra (alpine and arctic).
    - f. Swamps and marshes.
    - g. Aquatic.
      - 1. Ponds and lakes.
      - 2. Oceans.
  - 2. Plant associations.
    - a. Oak - hickory.
    - b. Beech - maple.
    - c. White pine - hemlock.
    - d. Cat tail - bur reed.
    - e. Sage brush - yucca.
    - f. Plus many others.
  - 3. Pure stands vs. mixed stands.
  - 4. Plant successions vs. climax associations.

C. Forests.
    1. Location of major forest areas in the United States.
        a. Northern coniferous forest - white pine, hemlock.
        b. Central hardwood forest - oak, hickory, beech, maple.
        c. Southern forest - sweetgum, long-leaf pine.
        d. Rocky Mountain forest - Ponderosa pine, Douglas fir.
        e. Pacific coast forest - redwood, Douglas fir.
    2. Ownership of the forests.
        a. Farmers - 34%.
        b. Private (non-farm) - 26%.
        c. Federal government - 21%.
        d. Forest industries - 12%.
        e. State governments - 7%.
    3. Forests in Pennsylvania.
    4. Uses of forests.
        a. Wood production.
            1. Construction.
            2. Furniture.
            3. Transportation.
        b. Major wood products.
            1. Lumber.
            2. Pulpwood.
            3. Christmas trees.
            4. Veneer and laminated wood products.
            5. Poles, posts, and mine timbers.
            6. Shingles.
        c. Distillation products.
        d. Food.
            1. Maple sugar.
            2. Nuts and fruits.
        e. Recreation.
        f. Watershed management (see unit on water).
            1. Flood prevention.
            2. Erosion prevention and control.
            3. Soil enrichment.
            4. Water retention.
        g. Wildlife.
            1. Food.
            2. Cover.
    5. Threats to the forests and plants in general.
        a. Lumbering.
            1. History.
            2. Methods of harvesting (in order of least desirable to most

desirable).
            - a. Clear cutting.
            - b. High grading.
            - c. Cutting to diameter limit.
            - d. Seed tree method.
            - e. Block cutting.
            - f. Selective cutting.
- b. Fire.
    - 1. Numbers.
    - 2. Types of fires.
        - a. Ground fire.
        - b. Surface fire.
        - c. Crown fire.
    - 3. Control.
        - a. Fire prevention.
            - 1. Education.
            - 2. Management.
        - b. Fire fighting.
            - 1. Fire towers.
            - 2. Fire lanes.
            - 3. Fire-fighting crews.
            - 4. Methods.
    - 4. Damages of fire.
    - 5. Causes in order of importance.
        - a. Smokers.
        - b. Incendiaries.
        - c. Debris burning.
        - d. Lightning.
        - e. Railroads.
        - f. Campers.
        - g. Lumbering.
        - h. Others.
- c. Diseases.
- d. Insects.
    - 1. Spray control.
    - 2. Biological control.
    - 3. Research.
- e. Grazing and browsing animals.
- f. Severe weather conditions.
    - 1. Wind.
    - 2. Ice.
    - 3. Snow.
    - 4. Drought.

      - 5. Floods.
    - g. Man.
      - 1. Open-pit mining.
      - 2. Highway construction.
      - 3. Industry and business expansion.
      - 4. Urban sprawl.
      - 5. Clearing for farming.
      - 6. Unnecessary cutting and clearing of land.
      - 7. Permitting overgrazing.
      - 8. Fires.
      - 9. Unwise farming practices.
      - 10. Unwise drainage.
  - 6. Preservation of forests.
    - a. Everyone's concern.
    - b. More efficient use of wood.
    - c. Government aids.
      - 1. Fire aid.
      - 2. Pest and insect control.
      - 3. Planting of seedlings.
      - 4. Research.
      - 5. Technical aid.
      - 6. Education.
      - 7. Legislation.
        - a. Zoning of forest lands.
        - b. Forest districts.
        - c. County supervision of private forest lands.
- D. Grasslands.
  - 1. Characteristics.
    - a. Size of grassland areas.
    - b. Ten to thirty inches of rainfall.
    - c. Usually fertile soil.
    - d. Numerous species of grasses.
    - e. Characteristics of grasses.
      - 1. Grow from the base.
      - 2. Grow close together.
      - 3. Have fibrous roots.
      - 4. Many are perennial.
      - 5. Many are drought resistant.

V. Uses of Plants
- A. Food for ourselves.
  - 1. Types.
    - a. Cereals (wheat, corn, rice, etc.).

    b. Legume fruits (beans, peas, etc.).
    c. Fruit crops (apples, peaches, etc.).
    d. Root crops (beets, turnips, etc.).
    e. Sugar crops (sugar cane, etc.).
    f. Beverages (coffee, tea, and chocolate).
    g. Flavoring and seasoning (pepper, vanilla, cloves, mustard, etc.).
  2. Methods of improvement.
    a. Careful selection of seed.
    b. Hybridizing.
    c. Grafting and budding.
    d. Use of soil testing.
    e. Better transportation of products.
  3. Food storage by plants.
    a. Carbohydrates (cereal plants and potatoes).
    b. Proteins (legumes and wheat).
    c. Fats and oils (nuts and olives).
    d. Minerals (leafy and root vegetables).
  4. Storage of plant foods by man.
    a. Canning.
    b. Drying.
    c. Freezing.
    d. Salting.
    e. Smoking.
    f. Freeze drying.
B. Feed for animals.
C. Fibers for making textiles.
D. Rubber.
E. Fuel.
F. Chemicals.
G. Medicines.
H. Decorations.
I. Lumber for construction.
J. Paper production.
K. Flood control.
L. Watershed management.
M. Soil conservation.
N. Wildlife management.
O. Recreation.
P. Water conservation.
Q. Research.
R. Paleoethnobotany.
S. Esthetic values.
T. Dyes.

VI. Unpleasant or Harmful Effects of Plants
  A. Poisonous to touch.
  B. Poisonous to eat.
  C. Allergies (ragweed).
  D. Weeds.

VII. Conservation of Plant Life
  A. Steps necessary to correct past mistakes.
    1. Wise management and utilization of present forest resources.
    2. Wise management and utilization of present grasslands.
    3. Reforestation and resodding when needed.
    4. Protection of plants from:
      a. Fire.
      b. Insects.
      c. Disease.
      d. Overgrazing.
      e. Man.

VIII. Basic Concepts
  A. All living things are dependent upon plants.
    1. Food.
    2. Clothing.
    3. Shelter.
    4. Oxygen.
  B. Plants are a renewable resource.
  C. Plants influence the:
    1. Soil.
    2. Water.
    3. Climate.
    4. Wildlife.
    5. Air.
    6. Other plants.
  D. Plants depend upon:
    1. Soil.
    2. Water.
    3. Sunlight.
    4. Air.
    5. Animals.
  E. Plants may be destroyed by:
    1. Disease.
    2. Insects.
    3. Fire.
    4. Man.

LEARNING ACTIVITIES AND MATERIALS

I. Learning Activities

A. Demonstrations.

1. Secure four glass tumblers, two pieces of 5" x 5" cardboard, and a leaf from an actively growing geranium plant. Punch a hole through the center of each piece of cardboard. Fill two glasses with water to within 1/2 inch of the top and place a piece of cardboard over each glass. Insert the petiole of the leaf through one of the holes so that the end of the petiole is at least 1/2 inch below the surface of the water. Be sure the other two glasses are dry and invert one over the leaf and the other over the glass that does not have a leaf. Observe at half-hour intervals for several hours.
2. Secure a pot of pea seedlings just emerging from the ground. Place on a window sill and cover with a cardboard box with a 2" x 2" hole in one side so placed that the hole is at the same height as the seedlings. Observe after 24 hours. Rotate the pot 180° and observe again after 24 hours.
3. Secure a variegated coleus plant in which part of each leaf is green and part white. Place the plant in direct sunlight for one day. Remove one of the leaves and treat as follows: (A) Place in boiling water for one minute. (B) Remove to warm alcohol (160° F.). (Chlorophyll is soluble in alcohol.) After the leaf has been decolorized, proceed to step C. (C) Place the leaf in a watch glass and add 10 drops of iodine solution (100 c.c. of water to which 1.5 grams of potassium iodide and 0.3 grams of iodine have been dissolved). Add enough iodine solution so that the entire leaf is covered with a film of the solution. Iodine solution is used to test for starch. When added to starch, a deep blue color develops.
4. Cover part of a leaf (top and bottom) on a growing geranium plant with a shield of opaque cardboard in the top of which several 1/2 inch holes have been punched. Expose to direct sunlight for one day. Remove the leaf and treat it the same as the coleus leaf in No. 3.
5. Fill a test tube (1" x 10") with water to which 5 drops of a concentrated solution of sodium bicarbonate (soda) has been added. Add a healthy sprig of Elodea to the tube (growing tip down) and place in the direct rays of the sun. If conditions are favorable, small bubbles of a gas (oxygen) will be liberated from the cut end of the sprig of Elodea. How many bubbles are liberated each minute? Shield the tube from the sunlight with a piece of cardboard and count the bubbles liberated per minute. Compare.

   Place several sprigs of Elodea in a beaker filled with water. Cover the cut ends with an inverted funnel and place an inverted test tube filled with water over the end of the funnel. The bottom of the test tube must be below the level of the water in the beaker. Oxygen now collects in the test tube. Test with a glowing splint when the tube is half full.

6. Prepare a solution of brome thymol blue by dissolving 0.3 grams of B.T.B. in 300 c.c. of water. Add one drop of ammonium hydroxide (dilute) to turn the solution blue. Brome thymol blue (an indicator) turns blue at a pH of 7 or above and turns yellow at a pH of 5.5 or below. Put 20 c.c. of the B.T.B. solution in a test tube and using a glass tube, blow your breath through the solution. It turns yellow because carbon dioxide from your breath dissolves in the water to form carbonic acid and lowers the pH to 5.5 or lower.

   Decolorize two tubes of brome thymol blue solution as mentioned above and place a sprig of Elodea in one and nothing in the other. Place both tubes in direct sunlight. After ten to thirty minutes, the solution in the tube containing the Elodea should turn blue while the other remains yellow. The Elodea used the carbon dioxide for photosynthesis.

7. Fill two test tubes with brome thymol blue solution. Place a sprig of Elodea in one tube--the other tube serves as a control. Place both tubes in the dark for 24 hours. The tube containing the Elodea will have turned yellow. Why? Plants give off carbon dioxide during respiration.

8. Soak a dozen kidney beans between two moist blotters until the seeds begin to germinate. Select three in which the hypocotyl has just emerged. Pierce each seed with a thin, stiff three-inch wire in such a way that in one seed the hypocotyl is projecting upward, in another downward, and in the other horizontally. Push the other end of the wire in a cork and place in a moist chamber in a dark place. Observe at hourly intervals for a day or two.

9. Place several pea seeds in a pot of soil, moisten, and set aside until the seeds begin to germinate. When the shoots are about one inch high, place the pot on its side in a dark place. Observe 24 hours later.

10. Line the bottoms of three Petri dishes with paper toweling. Place a dozen or more radish seeds in each dish and cover with more paper toweling. Moisten the toweling and place one Petri dish in a refrigerator, one in a very warm place, and one in a desk drawer at room temperature. Keep a record of the rate and percentage of germination for each Petri dish. In which dish do the seeds germinate first and why?

11. Fill a small flowerpot with dry bean seeds. Securely wire a thick piece of board over the top of the flowerpot and immerse the entire system in a pail of water. Within 24 hours the beans will have absorbed so much water and produced so much osmotic pressure that the flowerpot will be broken into a number of pieces.

12. Half-fill two wide-mouthed bottles with cotton or sawdust and saturate with water. Cover the cotton or sawdust with a layer of bean or pea seeds that have been soaked overnight in water. Insert a stopper in one; leave the other open. Add just enough water to the latter to replace losses from evaporation. After several days, conclude whether air is necessary for seed germination.

13. Cut a geranium stem diagonally with a sharp knife directly below a node leaving about three nodes in the cutting. Insert it about two inches deep in wet sand. Observe for several weeks.
14. Join a potato and tomato plant as follows: Grow both plants until about ten inches tall and then bring the two stems together. Shave the outer portion of each stem for a few inches where they will touch and then tie them together with soft cord. The two plants should grow together in about four weeks. If so, cut off the tomato stem below the graft and the potato stem above the graft. If the plant can be kept growing, it is possible to produce potatoes below the ground and tomatoes above the ground on the same plant.
15. Put a cup of water in a wide-mouthed bottle (a pint milk bottle is good), add two spoonsful of sugar, and crumble a half cake of yeast into the sugar solution. Attach a one-hole stopper to the bottle with a glass tube leading into a bottle of lime water. Observe at half-hour intervals for several hours. Results? What conclusions are justifiable?
16. Place some water-soaked corn seeds in a "tumbler garden". To make a "tumbler garden", cut a piece of blotter to fit around the inside of a glass beaker. Fill the center of the beaker with peat moss and keep it saturated with water. Push a few soaked seeds between the glass and the blotter. After the seedlings have grown an inch or two above the edge of the glass, fasten heavy rubber bands around the glass to keep the contents from slipping out. Then suspend the glass in an inverted position from a support and observe what happens to the direction of growth of both the roots and stems.
17. Cut off the bottom inch of a stalk of celery with a sharp knife. Place it in a glass of red ink. Note the conducting vessels of the celery.
18. Obtain two seedlings of approximately the same size. Treat one with gibberellin. After several days, compare the two plants as to size, weight, etc. What conclusions can be justified? Is this chemical going to help increase food production in the future?

B. Field trips.
   1. To a Christmas tree farm.
   2. To a modern maple sugar camp.
   3. To plots of experimental grasses and crops planted on local farms.
   4. To a sawmill to see how lumber is cut.
   5. To a fire tower and have the forester demonstrate how fires are spotted and controlled.
   6. To a local wooded area to check for fire, insect, grazing, or wind damage.
   7. A fall field trip to fields and forests to study seed dispersal.
   8. A winter field trip to study plant buds.
   9. To learn tree identification by leaves, bark, flowers, and shape.
   10. To the same local forest area in the fall, winter, spring, and summer to note seasonal changes in plants.

11. To the agricultural exhibit at a fair.
12. To a freshly cut tree stump.
13. To a tree nursery.
14. To a state forest or park.
15. To study spring wild flowers.
16. To an abandoned strip mine to note plant growth and look for fossils.
17. To Phipps Conservatory (Pittsburgh) to see a flower show.
18. To a greenhouse or a florist's shop to see how flowers are handled and sold.

C. Discussion.

1. How do plants prepare for winter?
2. What causes fall coloration in leaves?
3. How are seeds disseminated?
4. What is the effect of light on plants (photosynthesis, phototropism, photoperiodism, and etiolation)?
5. What plants furnish winter food for birds? Summer food?
6. How can a covering of snow protect plants?
7. What causes hay fever?
8. What are the oldest living things? The biggest? The tallest?
9. What is a hot bed? A cold frame?
10. What are the advantages and disadvantages of the different methods of harvesting trees?
11. How does overgrazing of a pasture (forest) injure the area?
12. What is a food chain? What part do green plants play in a food chain?
13. What is nitrogen fixation? Where and how does it take place?
14. What is the name of the watershed in which you live? How can it be improved?
15. Comment on the statement: "When the forest dies, we die."
16. How do forests benefit soil, water, wildlife, and man?
17. Discuss how the forests helped settle America.
18. What is the significance of grass to our nation?
19. Debate: The oxygen cycle poses no problem for a modern technological society like ours.

D. Bulletin board displays to illustrate:

1. Leaves of common trees of the area (print, smoke prints, or pressed leaves).
2. Wild flowers that should be protected.
3. How to transplant a tree.
4. Parts of a typical flower or tree.
5. Life cycles of various plants (fern, mushroom, or moss).
6. Lines of plant evolution.
7. Products made from trees.
8. Forest areas and grasslands of Pennsylvania, the United States, and the world.

9. Causes of forest fires.
10. How to prevent forest fires.
11. Common plant diseases.
12. Insect pests of plants.
13. Poisonous plants of the area.
14. Edible wild plants of the area.
15. The ways in which soil, water, plants, animals, and man depend on each other.
16. Where our chief crop plants, such as: wheat, corn, tobacco, potatoes, etc. are grown.

E. Student activities and projects.
   1. Develop a nature trail on or near the school grounds.
   2. Carefully examine and dissect a flower. Identify all parts and give the function of each.
   3. Start a leaf collection. Collect and identify leaves of the common trees in the area.
   4. In the fall, collect and identify the different kinds of mushrooms, mosses, ferns, lichens, etc.
   5. Germinate the spores of a fern on a moist flowerpot.
   6. Germinate pollen grains in a sugar solution. Examine under a microscope.
   7. Place a potato in moist sand. Note that it shrivels up as shoots are produced from the "eyes".
   8. Set up and care for a terranium (forest, bog, and desert).
   9. Find areas of erosion in your area and transplant tree seedlings to help check erosion.
   10. Make a list of the trees in your area that shed their leaves in the fall and those that do not shed their leaves.
   11. Moisten a slice of bread and place aside for several days. Note the different kinds of molds that appear.
   12. Collect samples of different kinds of lumber (oak, yellow pine, maple, chestnut, hemlock, etc.). How do they differ?
   13. Make Christmas decorations from pine cones and "weeds".
   14. Test various vegetables and plant parts for starch, sugar, protein, and fat.
   15. Consult your district game protector to see what forest practices are being used to provide food, cover, and protection for wildlife.
   16. Select several different forest areas and compile a list of the plants that grow best in the various areas. Are there any differences? What are the reasons for the different plants?
   17. Make leaf prints of the common trees in your area.
   18. Germinate different kinds of seeds in a rag-doll germinator. Note the per cent of germination.
   19. Collect pond water and study it under a microscope to observe the many kinds of algae that are present.

20. Using a microscope, note the structure of the cell of an onion.
21. Write a paper on the opening of the western cattle-raising era and its impact on United States history.
22. Write a paper on the history of the sale and use of public land in our country.
23. Place a board over some green grass on the lawn for a period of four or five days. Remove the board and compare the color of the grass under the board with the grass that was not covered. Results? Conclusions?
24. Soak several grains of corn and several lima beans in a glass of water overnight. Use a sharp knife to cut the grain lengthwise. With a hand lens, observe the seed coat, endosperm, and embryo. What is the function of each part? Remove the seed coat from the lima bean. Note that there is no endosperm. The bean seed consists of only two parts, seed coat and embryo.
25. Using the embryo of the bean seed in No. 24, pry the two cotyledons apart and note the hypocotyl, plumule (epicotyl), and radicle. What is the function of each part?

II. Learning Materials
    A. Audio-visual materials.
        1. See list of sources at the end of the guide.
    B. Books and pamphlets.
        1. Ayres, Robert V., "Food", Science Journal, Vol. 3, No. 10, pp. 100-106, October, 1967.
        2. Brown, Harrison, The Challenge of Man's Future, Chapter IV, "Food", The Viking Press, 1953.
        3. Cluett, The Story of Cotton, Peabody and Company, Inc., Educational Service Department, 530 Fifth Avenue, New York 36, New York.
        4. Cole, Lamont C., "Man's Ecosystem", Bioscience, pp. 243-248, April, 1966.
        5. Fernald, Merritt L., Gray's Manual of Botany, 8th Edition, American Book Company, New York, 1959.
        6. Finch, Trewartha, and Shearer, The Earth and Its Resources, McGraw-Hill Book Company, 1941.
        7. Fischer, Richard B., Editor, Our Living Worlds of Nature, McGraw-Hill Book Company.
            Life of the Forest, McCormick, Dr. Jack, 1966.
            Life of the Mountains, Brooks, Dr. Maurice, 1967.
            Life of the Prairies and Plains, Dr. Allen, 1967.
        8. Flynn, Harry E. and Perkins, F. C., Conservation of the Nation's Resources, MacMillan Company, New York.
        9. Fuller, Harry J., The Plant World, Holt and Company, New York, 1959.
        10. Galston, A. W., The Life of the Green Plant, Prentice-Hall, 1961.

11. Goddard. M. K., Conservation of the Natural Resources in Pennsylvania, unpublished reprint from the Department of Forests & Waters, Commonwealth of Pennsylvania, 1963.

12. Grenbach, V. A. and Adams, J. E., Plants, an Introduction to Modern Biology, Chapter I, "Plant Resources", pp. 3-26, J. Wiley and Sons, 1967.

13. Hammond, Winifred G., Plants, Food, and People, Coward-McCann, Inc., New York, 1964.

14. Hersey, Jean, Wild Flowers to Know and Grow, D. Van Nostrand Company, Inc., New York, New York, 1964.

15. Hillcourt, William, Field Book of Nature Activities, G. P. Putman's and Sons, New York.

16. Holbrook, S. H., Burning an Empire, The MacMillan Company, New York.

17. Holbrook, S. H., Tall Timber, The MacMillan Company, New York.

18. Hout, Joseph B., Man and the Earth, Prentice-Hall, Inc., 1967.

19. Knobloch, J. W., Editor, Selected Botanical Papers, Prentice-Hall, Inc.

20. Lansberg, H. H., Fischman, L. L., and Fisher, J. L., Resources in America's Future, Chapter 2, "Food", The Johns Hopkins Press, 1963.

21. Life Nature Library, Ecology; the Forest; and the Plants, Time, Inc., New York.

22. Morholt, Brandwein, and Joseph, A Sourcebook for the Biological Sciences, Harcourt Brace and Company, 1958.

23. Muenscher, Walter C., Poisonous Plants of the United States, MacMillan Company, 1958.

24. Myers, J. Walter, Ten Lessons in Forestry, Arkansas Forestry Commission, Little Rock, Arkansas, 1965.

25. Parker, Bertha Morris, Science Experiences, Row Peterson and Company, 1959.

26. Partridge, J. A., Natural Science Through the Seasons, MacMillan Company, Toronto, 1966.

27. Pettit, Ted, The Book of Nature Hobbies, Didier Publishers, New York.

28. Riley, Denis and Young, Anthony, World Vegetation, Cambridge University Press, New York, 1966.

29. Scrimshaw, N. S., "Food", Scientific American, September, 1963.

30. Shippen, Katherine B., Great Heritage, The Viking Press, New York.

31. Smith, Guy Harold, Conservation of Natural Resources, 3rd Edition, Guy Wiley and Sons.

32. Whaley, et. al., Principles of Biology, 3rd Edition, Harper and Row, New York, 1964.

33. Wilson, C. L. and Loomis, W. E., Botany, Chapter II, "Plants, Their Nature and Use", The Dryden Press, 1967.

34. Common Trees of Pennsylvania, Pennsylvania Department of Forests & Waters, Bureau of Forests, Harrisburg, Pennsylvania.

35. It's a Tree Country, American Forest Product Industries, Inc., 1835 K Street, N. W., Washington, D. C. 20006, 1967.

36. Managing the Family Forest, Bulletin No. 2167, United States Department of Agriculture, Washington, D. C.

37. People and Timber, United States Forest Service, Washington, D. C.

38. Rubber, The Firestone Tire and Rubber Company.

39. The Forest Adventures of Mark Edwards, American Forest Products Industries, Inc., 1967.

40. The Story of Cotton, National Cotton Council of America, P.O. Box 12285, Memphis, Tennessee.

41. The Story of Forests, American Forest Products Industries, Inc., 1835 K Street, N. W., Washington, D. C. 20006, 1967.

42. The Story of Natural Rubber, National Rubber Bureau, 1103 Sixteenth Street, N. W., Washington, D. C. 20036.

43. Timber Resources for America's Future, United States Forest Service, Washington, D. C.

44. Trees, Yearbook of Agriculture, United States Department of Agriculture, Washington, D. C.

45. Trees for Tomorrow, American Forest Products Industries, Inc., 1835 K Street, N. W., Washington, D. C. 20006, 1967.

ANIMALS

BACKGROUND INFORMATION

Animals are a major source of food for Americans. Food animals may be divided into either domestic or wild animals. The production of domestic animals for food is a multi-billion dollar industry in the United States. Domestic animals have been improved by research, selective breeding, and hybridizing. Local and national groups, such as 4-H clubs, F. F. A., county agents, and educational institutions, have stressed the value of scientific farming.

In the United States and Canada, animals provide two-thirds of the protein in human food. Proteins are the most expensive and scarce of all foodstuffs and are an essential part of the diet.

In densely populated countries, people and animals actually compete for proteins. The great majority of animals are nourished by food which is grown on land that could otherwise be utilized for the direct production of food for man. For this reason, in areas of high population density, such as China, people live primarily upon a vegetable diet. The luxury of spending seven vegetable calories to obtain one meat calorie cannot be afforded.

Wild animals are also a source of food. In Pennsylvania, rabbits, pheasants, grouse, deer, bear, and fish are the major wild animals harvested each year under the supervision of the Pennsylvania Fish Commission and the Pennsylvania Game Commission. In 1964, United States big game hunters harvested two million head of game ranging from wild boar in Hawaii, elk in Colorado, to caribou in Alaska. This game dressed out in excess of 233 million pounds of meat. In the same year, hunters shot over eight million wild ducks and geese, plus 91,000 wild turkeys. This does not include the meat derived from small game hunting.

Fish are also a major source of animal proteins. About three-fourths of the annual world catch of 46 million tons is used for human consumption. On a world basis, this amounts to 22 pounds per person in comparison with 20.5 and 20.3 pounds of beef and pork per person respectively.

Some experts in marine resources believe that ninety per cent of the ocean's productivity is unused and that utilization can eventually be increased five-fold. If so, with sound management and conservation, the world's oceans could produce two hundred million tons of fish annually.

Animals also serve as a source of clothing. Leather is obtained from the hides of cattle, horses, reptiles, pigs, and deer. Wild fox, muskrats, racoon, skunk, and beaver are the mjaor fur-bearers trapped in Pennsylvania. Most mink pelts are produced on mink farms. Silk is produced by the silkworm, and wool is obtained from sheep. The list also includes mohair, cashmere, and goat and camel hair from the goat family. Birds provide down (goose) for insulation and feathers for decoration (ostrich).

Animals serve as "guinea pigs" for scientific research to produce vaccines and antibiotics and as a source of medicine. For example, the polio vaccine is cultured in eggs and diptheria vaccine is produced in a horse's bloodstream. Cobra venom is being used to fight the pain associated with cancer, and rattlesnake venom is used for arthritis treatment. New ideas in medicine are used on animals before they are used on human beings. For example, the first heart transplants were conducted on dogs.

Plant and animal populations in nature may be profoundly effected by a seemingly non-related change in the environment. Charles Darwin pointed out that the number of old maids in a community affects the yield of the clover crop. His reasoning was as follows:

> Old maids keep cats; more old maids, more cats. Cats eat mice; more cats, fewer mice. Meadowmice form underground nests that are frequently used by bumblebees the following year as nesting sites; fewer mice, fewer nesting sites for bumblebees; hence, fewer bumblebees. Bumblebees pollinate clover; fewer bumblebees, fewer seeds of red clover; and, therefore, fewer plants the next year.

Under ideal living conditions, all living things have the ability to reproduce at a rate which permits the population to expand at an alarming rate. For example, many bacteria are able to divide every hour. At this rate, one bacterium would have over 16,000,000 descendants in twenty-four hours.

The theoretical maximum rate at which a species can increase in numbers is known as the "reproductive potential". Fortunately, there are a number of factors that tend to prevent any species from multiplying at this maximum rate indefinitely. Food supply, disease, enemies, fire, floods, drought, overgrazing, even space itself, all tend to prevent such a rapid increase in numbers. Collectively, these factors are called "environmental resistance".

The actual number of individuals of any species present at any given time is the result of the interaction of these two factors--reproductive potential and environmental resistance. Mathematically, it would be:

$$\text{Population} = \frac{\text{Reproductive Potential (R. P.)}}{\text{Environmental Resistance (E. R.)}}$$

For most species, the reproductive potential (R. P.) is, for all practical purposes, a constant. Therefore, when the environmental resistance (E. R.) increases, the population decreases and vice versa.

The lemmings of the far North illustrate this relationship. Given several years of abundant food, the lemmings increase in numbers to such proportions that the Arctic tundra is unable to support the millions of rodents. They swarm over the countryside in vast hordes consuming all vegetation. With the food supply now exhausted, the E.R. increases; and the lemmings are doomed. Millions attempt to migrate to new areas but are drowned in the sea; other millions die on the tundra. With the lemming population at a low ebb, the vegetation recovers; the E.R. now decreases and once more the population begins to increase, slowly at first, then more rapidly and in several years, the cycle is repeated.

These animals which face many hazards (high environmental resistance) (prey) have a high reproductive potential; those which face few hazards (predator) (low environmental resistance) have a low reproductive potential.

Symbiosis refers to the intimate association of two dissimilar organisms. If one organism (parasite) lives in or on another organism and benefits from the association while the host is harmed, it is called parasitism. The organism that transmits the parasite from host to host is called a vector. The transmission of the malarial parasite from human to human by the Anapholese mosquito is an example of this. The suckerfish attached to a shark is an example of commensalism. The suckerfish benefits from the association, but the shark is neither benefitted nor harmed. In a mutualistic association, both organisms are benefitted and neither is harmed. The flagellates living in the intestines of a termite digest the cellulose for the termite while the termite provides a "home" and protection for the flagellates.

Predators are animals that prey upon other animals (see unit on plants). In general, predation is a valuable natural means of preventing herbivorous animals from becoming too numerous. It is a part of the system of "checks and balances" that pervades the entire biological world.

The following considerations may help to give proper perspective to this interesting inter-relationship:

1. A predator is an animal that lives by preying upon other animals.
2. Nearly all animals may at times be predatory.
3. Man is one of nature's most destructive predators.
4. Predators may be harmful or beneficial. If they prey upon rodents or vermin, we consider them beneficial. If they prey upon beneficial animals, we consider them harmful.
5. Predators frequently prey upon weak, sick, or diseased animals; therefore, they leave the healthy ones to reproduce their kind--thus tending to improve the vitality of the prey.

6. Some predators are highly valued for their fur.
7. Some predators have a high recreational and esthetic value (for example, the fox, owl, and hawk).
8. Predators tend to keep rodents and grazing animals from becoming too numerous.
9. Some predator control may be helpful, but we must never attempt to achieve extermination.
10. In an attempt to control predators man has tried (1) professional hunters and trappers, (2) the bounty system, (3) poisoning, and (4) biological controls.

In nature, every species of plant and animal appears to have not one, but many enemies (diseases, parasites, etc.). These factors tend to keep the plant or animal from becoming too numerous. However, there have been numerous interesting examples of species that have been transported from their native homes to new areas where the normal enemies have not been present. Such species are referred to as exotics. Freed from the normal checks on population increase, exotics sometimes reproduce to such an extent that the normal balance of nature is greatly altered. Most of our crops and domestic animals, many of our noxious weeds, insect pests, and plant diseases as well as a few fish, birds, and mammals are exotics. The English sparrow was brought into the United States from England. The bird did not have the natural enemies here that it had in England. Consequently, the sparrow population increased at such a rate that it is now regarded as a pest. The following list shows other animals that were imported into favorable environments that did not contain the checks and balances of the native environments:

1. English sparrow (house sparrow).
2. Starling.
3. Ring-necked pheasant.
4. Carp.
5. Rabbits in Australia.
6. Coddling moth.

Scavengers are the custodians of nature and include those animals such as the lobster, crayfish, opossum, hellbender, and turkey vulture that eat animals which have died.

It is generally known that many birds go south for the winter, but it is not so well known that the Monarch butterfly, fur seals, whales, and several species of bats regularly migrate southward each winter. Migration also includes seasonal movements from a place of higher elevation to a place of lower elevation as is the case of the elk and other members of the deer family. Some amphibians move from the land to the water to spend the winter. Other animals, such as the salmon, migrate from salt water to fresh water to spawn.

Hibernation, an adaptation for cold weather survival, is a deep, prolonged sleep during which the body temperature drops and vital processes are greatly curtailed.

Estivation refers to the passage of hot, dry weather by the animal in a dormant state. Some frogs burrow into the mud of streams to survive hot, dry weather. The African Lung fish practices estivation also. When the streams dry up, it buries itself in the mud until the rains come, and the streams return to normal volume.

Other animals store food for use during severe weather conditions. Typical examples include the squirrel and beaver.

Those animals which remain active during cold weather usually develop a thick fur for protection. Some animals turn white in winter (weasels, snowshoe rabbits, and ptarmigan), thus becoming less conspicuous against a background of snow.

The reproductive cycle of animals is associated with seasonal changes. As the seasons change, so does the temperature and the length of daylight and darkness. Biologists think that it is the increasing and decreasing amount of light and darkness that triggers the reproductive drive in the various animals.

An animal must live in its environment and adjust to the various conditions and influences present. These conditions and influences are called factors of the environment.

There is probably no environmental factor more important to living things than the water supply. Animals living in fresh water are called aquatic, and those living in salt water are called marine. Many aquatic environments are relatively stable because water is retained by freezing in winter and that lost by evaporation in summer is replaced by rains. However, floods and droughts create habitat changes which threaten aquatic species.

The degree of hotness or coldness of any body is called temperature. Cold-blooded animals do not have any method of maintaining a constant body temperature. Therefore, their metabolic rates, growth, and activities are regulated by environmental temperatures. The warm-blooded animals have regulated body temperatures and can remain active in climates with large temperature variations provided adequate food and shelter is available.

The atmosphere constantly exerts atmospheric pressure which varies with the elevation above sea level. At high altitudes where air pressure is low, the oxygen supply is less, and animals have larger hearts and more red blood cells to carry oxygen for respiration.

When the first Europeans came to America, they found a continent teeming with an abundance of wildlife. The colonists, as had the Indians, found this abundant wildlife an important and relatively easy source of food. Small wonder then that the early colonists harvested the crop recklessly. In a few years, game shortage began to occur along the Atlantic Coast. The colonists simply moved inland, and the slaughter continued.

Furs were used as an export item to trade for European goods. In fact, furs became the economic basis for many of the colonies, particularly New York, and were used as a substitute for money well into the nineteenth century. The quest for furs led to the formation of joint-stock companies, such as the Hudson Bay Company. The lure of the Pacific Northwest led to the formation of the American Fur Company headed by John Jacob Astor, who became America's first millionaire. The fur trapper from the time of Lewis and Clark provided a willing tool for expansion of Manifest Destiny. The mountain men penetrated farther and farther into the continent. They were the "advance men" exploiting the beaver and the sea otter in ruthless competition with the British. Civilization followed them. However, the two were incompatible. Permanent settlements either destroyed or drove away most of the fur-bearing animals. Thus, the trapper moved farther west and north. The fur industry provided the incentive for exploration and expansion, as well as the capital, to start other businesses. In fact, some of the greatest cities in the United States were founded on fur-trading. Detroit, Chicago, St. Louis, Buffalo, and many others were helped on the way to urbanization by the fur-trading industry.

The slaughter of the buffalo began after the American Civil War. Buffalo had once roamed into Pennsylvania and North Carolina. However, as the frontier moved westward, the buffalo were pushed into the Great Plains. It should be mentioned that there were two species of buffalo in the United States. The Woods Buffalo were found in the eastern wooded section, and the Plains Buffalo were found in the midwestern section of the United States. The former were exterminated, and the latter were saved from extinction by careful control and management of the herd which continues today.

The plains Indians were very dependent on the buffalo. The meat was a large part of their diet. The hides were used for clothing, housing, etc. and the bones for implements and weapons. Even the dung was used for fuel. The railroads, particularly the Union Pacific, cut the herd in half and opened the area to slaughter. Buffalo robes became a status symbol in American homes. In addition to the hide, the tongue and a few choice parts would be taken, and the rest was left to rot. About three million buffalo were killed each year between 1871 and 1874. By 1883, there were only one thousand head left in the northern herd. The slaughter of the buffalo also sounded the end for the plains Indians. The Indians' choice was either the reservation or starvation.

Before the white man arrived, the Indians practiced a crude form of conservation. They hunted and fished only to fill their own immediate needs. Only from the white man did the Indian learn the profit motive of trading furs, etc. for whiskey, beads, and guns. As the Indians were pushed west, the white hunters replaced them, and the big game animals were systematically depleted.

The passenger pigeon was slaughtered the same as the buffalo. However, the destruction was complete and by 1914, not one passenger pigeon was left. At the time of their extinction, hunters were receiving one cent a bird.

In regard to fishing, the colonists found fish in abundance. Rivers and lakes were well stocked. Many New England towns and cities based their existence and wealth on the fishing industry. Salted cod became the most important item in New England's triangular trade with the West Indies and Europe and provided currency and goods for the New Englanders. The eighteenth and nineteenth centuries saw the advent of whaling. By 1840, "Yankee Clippers" could be found anywhere in the world.

The Gulf Coast became a leading center for fishing. The Pacific Coast established a fishing industry on salmon and halibut. By 1878, the Alaskan Salmon Cannery industry was underway.

Of all animals on the American continent, the deer were among the first to show a decrease. However, they fared better than the buffalo or passenger pigeon. In 1721, Sir William Keith, Governor of Pennsylvania, enacted Pennsylvania's first game law. This was the first step taken in the direction of wildlife management in Pennsylvania. Deer-hunting laws were also passed in New England. Following the lead of Connecticut and Massachusetts in 1698, most of the colonial legislatures passed regulations by 1750. Game wardens or "deer reeves" were appointed to enforce the laws. Deer were the only animals protected until Maryland regulated waterfowl hunting in 1842.

For many years, this was the nature of most wildlife management programs. Whenever a game species began to decrease in numbers, laws were passed limiting the number that could be taken and closing the hunting season during the breeding period. However, such laws were not popular and there were few, if any, law enforcement agents. As a result, the game continued to decrease in numbers.

In 1866, the first fish commissioner was appointed in Pennsylvania. A fish commission of three persons was founded in 1873. In 1878, California and New Hampshire established state fish and game commissions to protect and conserve the wildlife. By 1900, most states had deputized game wardens to enforce the laws, but game remained in short supply.

In 1908, President Theodore Roosevelt called a conference of governors and some cabinet members to consider ways and means to preserve the nation's natural resources. From this commission came a national conservation commission and a number of state commissions. In 1916, the National Park Service was created by Congress to provide protection for all wildlife within the parks. In 1929, the Norbeck-Anderson Migratory Bird Conservation Act provided for the development of national bird refuges. The Antiquities Act, passed in 1906, gave the president the right to set aside national monuments. By 1947, two hundred ninety-one federal wildlife refuges were founded.

Wildlife refuges were established to give game a secluded area in which to breed, and an attempt was made to eliminate the natural enemies of the game. Thus, predator control was born. However, by releasing a herd from the normal stress of predation, overpopulation results. An example are the elk of Mt. Olympus National Park. Due to a lack of predators, some ten thousand animals were living in an area capable of supporting only five thousand. In 1965, government hunters were forced to slaughter over six thousand head of elk in order to stabilize the herd.

In 1683, Pennsylvania initiated the bounty system to control predators. It was ended in 1966 because the results did not justify the cost. Most predators are killed as an incidental part of other outdoor recreation activities rather than by bounty hunters. Research has shown that the predator population experiences a seventy per cent annual turnover. Therefore, bounty hunters would have to kill more than seventy per cent of the predator population to affect a change in the overall population. This has not happened. As a result, the money previously spent on bounties to increase small game populations will produce more favorable results by being used for habitat improvement. In fact, the culling effects of predation helps to maintain wilder and stronger game populations.

It seemed logical that where nature had failed to produce enough game, man should take over and rear the animals on game farms and turn them loose to restock an area.

Habitat improvement, the central theme of wildlife management today, seems to be the best answer to the wildlife problem. If you manipulate the habitat so as to supply food, water, and shelter, game will usually increase in numbers.

The farmer, like all businessmen, is in business to make money. Game is a crop; but since it belongs to the state, it cannot be considered a cash crop. However, it is to the farmer's advantage to encourage game by any practice that will not interfere with his regular farm program. By encouraging game to be present, the farmer receives help in controlling insect pests under natural conditions. He is helping to maintain nature's system of checks and balances for which man has not found a better method. The following practices have been found to encourage wildlife and to be compatible with good farming:

1. Utilize waste space, such as gullies, stream banks, etc. to provide food and cover. Several small areas are preferable to one large one. Plant food-producing trees and shrubs.
2. Manage farm woodlot areas.
3. Allow fence rows to grow up in shrubs.
4. Construct farm ponds (fence them off from grazing cattle).
5. Utilize cover crops.
6. Permit small patches of grain to remain unharvested.
7. Delay the plowing of stubble until spring.
8. Utilize a flushing bar on mowing and harvesting machines.
9. Eliminate stray dogs and cats.
10. Prevent soil erosion.

Conservation of migratory waterfowl is complicated for several reasons. Waterfowl are particularly vulnerable to water pollution. Since they nest in marshy areas, they have been hard hit by the many drainage problems in the United States. Also, because of their migratory habit, it is difficult to give them ample protection. Some species nest in Canada and winter in the Caribbean. They pass through this country during the spring and fall migrations but spend most of their time elsewhere. This clearly indicates the international cooperation needed to conserve wildlife. The Migratory Bird Act of 1913 and the Migratory Bird Treaty Act of 1918 are examples of such cooperation.

In the United States, the state governments are responsible for the protection of non-migratory species; the federal government is responsible for the protection of migratory species.

The story of fish has been essentially the same as that for other forms of wildlife. It is the story of early abundance, misuse, and later scarcity. Since fishing is probably America's most popular outdoor hobby, fish commissions are giving increasing amounts of attention to fish conservation. Fresh-water fish management consists of establishing seasons, size and creel limits, fish hatcheries for restocking purposes, habitat improvement, and manipulation of fish population.

Since fish are highly prolific (high reproductive potential), predation is less of a problem than on land. However, water pollution is a deadly problem. The construction of dams for irrigation, flood control, power, etc. has given rise to fish problems. Dams change the environment of a stream so drastically (temperature, food, oxygen, shelter, and silt) that they alter the species of fish that may be present.

Farm ponds have greatly increased the fishing potential of the country. With proper pond management, it is possible to produce more meat/acre in a farm pond than on a farm pasture. Shallow water is much more productive than deep water.

Fresh-water fishing is chiefly recreational, whereas marine fishing is chiefly commercial. This must be kept in mind for any proposed program.

Air, sunshine, soil, and water are the bases on which renewable resources are built. Therefore, any practice that has an adverse effect on any of the four will reduce the population of plants and animals on which man depends for food and recreation.

A great concern for wildlife is the enormous growth in the use of pesticides and weed killers for insect and weed control. It is not only the wildlife itself, but also the food supply that is lost. Studies have shown that not only fish are killed, but also the aquatic insects upon which the fish depend for food. The most serious problem seems to be the residual effect of the poison long after the original usage. Hydrocarbon pesticides have a long life without chemical breakdown and accumulate in the soil and water. This accumulation of sublethal doses occurs in the animal's body and accumulates as it progresses up the food chain. The following example will illustrate this residual and accumulative characteristic of various pesticides:

> D. D. T. was applied to Clear Lake in California in several treatments within eight years in very dilute quantities (1 part of insecticide to 50 million parts of water). The D. D. T. killed the gnats. It was also eaten and concentrated 250 times by the water plankton. It was found in 500 times concentration in the small fishes that ate the plankton. It killed most of the western grebes that ate the fishes, and they died with an 80,000 times concentration.

A biological habitat is a community of inter-related organisms. Any factor which throws the community off-balance may have far-reaching and unpredictable effects. The indiscriminate use of pesticides on numerous occasions has been responsible for throwing a biological community off-balance to such an extent that numerous beneficial forms of wildlife have been killed. The following are examples:

1. In Connecticut, D. D. T. sprayed on elms to control the Dutch Elm Disease killed thousands of songbirds.
2. In Alabama, insecticides used to control cotton pests killed thousands of fish in the Tennessee River.

The list is almost endless. However, no sensible person would suggest the elimination of pesticides from the weapons used by man to control nature. However, before using a pesticide, research should be conducted to determine the potency and residual effect of the poison. Laws should be passed to prevent careless use of pesticides, and the public should be educated concerning the use of pesticides.

Zoologists recognize from twenty to twenty-five phyla of animals depending on the authority that is consulted. However, for the average person, ten phyla of animals should be sufficient. Ninety-nine per cent of all of the animals that one is apt to encounter will be in one of the phyla listed in the outline.

There are probably several million distinct forms of animals. This great diversity is spread over a wide size range--the largest forms being around ten million times larger than the smallest. In addition to diversity of size, there is a diversity of form (structure), function, and habitat. Such enormous diversity requires a system for categorizing which will result in a more comprehensible body of information--today this system is termed systematic taxonomy. First attempted in 1753 by the botanist, Karl Von Linne, taxonomy has undergone vast changes in concept and underlying theory since its conception. It is now accepted that there are many kinds of taxonomic structuring. Living animals are classified at present on the basis of their morphology and inter-reproductive ability, and most recently, on the basis of their gross overt behavior. For example, the Java Macaque monkeys are able to interbreed with the Pigtail Macaque monkeys and produce normal, fertile, viable offspring; but seldom does such behavior occur. These animals are considered different species by some taxonomists who stress morphology alone. However, if these two groups can interbreed successfully, then their genetic bases are identical, or at least quite similar. If their behavior pattern is the only factor that maintains their respective identities, is it valid to call these two, separate species? This is the kind of problem upon which taxonomists, biologists, and quanitative zoologists must focus.

The belief that animals evolve is an old one, but it became generally accepted only through the efforts of Charles Darwin. The careful "pigeonholing" of Linne's classification, which focused on naming organisms that looked different, was somewhat altered by the fluid species concept of Darwin. To Linne, species was a fixed and unalterable thing. The acceptance of the concepts of evolution led to changes in taxonomic methods in order to take into account that all living things evolve, species change over time, and there is an interrelationship between heredity and environment which results in the gross behavior of an animal population. In other words, there is no right taxonomy; it varies according to the researcher.

Populations evolve by means of adaptation to an environment. Adaptation is accomplished through the interaction of the animal form and its physical and/or biological environment. The environment stresses the population; certain segments of the population are able to continue producing fertile, viable offspring. The remaining portions of the population are not able to produce as many fertile, viable offspring; and, eventually, they are no longer able to compete reproductively. This is a simplified explanation of natural selection. The remaining evolutionary principles are: gene mutation, migration of populations, and genetic drift. A mutation involves a change in DNA structure, an alteration of chromosome material, or a new gene formation. Population migration results in the introduction of new genetic material to another group (gene recombination). Genetic drift is the accidental loss of genes through loss of a segment of the population. For example, assume that in a population of 280 chimpanzees, only eleven males have an eye disease (holandric) which is genetic. If all eleven males are drowned as the group is crossing a river, the genotype is lost to the population. This population has undergone genetic drift.

Once a population has undergone change, by the methods noted above, natural selection acts to achieve a natural balance which is called adaptation. Once achieved (if ever possible), natural selection acts to maintain the balance. A perfect balance cannot be achieved, but a balance within prescribed limits with small fluctuation can and must be achieved and maintained.

For most species, the greatest source of stress can be traced to man. Draining swamps, building roads, and dams, urban sprawl, etc. are activities of man that constantly alter the animal's environment. If a species is to survive and compete with man, the animal population must have a capacity to evolve rapidly to fit local conditions; and individual animals must have the capacity to learn new habits of survival under altered circumstances.

Biologists stress the fact that the cell is the basic building block of all living things. There are many kinds of cells, such as muscle, nerve, secretory, etc. Two or more cells working together to perform a certain function make up a tissue. Tissues working together to perform a function constitute an organ. Organs in turn make up systems and systems make up the individual.

In order for a cell to function properly, certain conditions or requirements must be met.

Food is any material used by an organism to supply energy or to construct protoplasm. In order for food to pass into a cell, the food must be in a soluble form. The conversion of an insoluble food to a soluble form is called digestion and is brought about by enzymes. Once within the cell, the soluble foods may be respired to release energy, or they may be combined into new compounds to form the various cell structures. The process of digestion may take place in various structures ranging from one cell to complete digestive systems. In the protozoa, the food particles are digested in a food or gastric vacuole within each cell. The Coelenterates have an incomplete digestive system (only one opening to the digestive cavity). The food enters throught the mouth, is digested in the enteron, and waste material is ejected through the mouth. In other groups of animals, there is a complete digestive system (two openings to the digestive system). Food enters through the mouth and undigested material leaves by way of the anus.

Oxygen is needed for respiration. Oxygen combines with the chemical elements of the food to produce carbon dioxide, water, and liberate energy. Respiration must take place in all cells in order for life to continue. In the lower forms of life, oxygen diffuses through the plasma membrane or through the body wall; no special structures are needed. In many higher aquatic forms, gills are present. In terrestial forms, such as insects, oxygen enters through spiracles into the trachea which branch to all parts of the body. In reptiles, birds, and mammals, the lungs are responsible for supplying the oxygen.

Waste products, such as urea, inorganic salts, etc., must be removed from a cell or death from uremic poisoning results. In the lower forms, waste materials may diffuse through the plasma or body wall to the outside. In the higher forms, specialized structures (kidneys in man) have evolved for waste removal.

In many lower forms, diffusion between cells and through the body wall is all that is necessary to take care of the transportation needs of the organism. However, in the higher forms, a circulatory system is needed to (1) carry food to each cell of the body, (2) carry waste materials from each cell to the excretory organ, (3) carry oxygen to each cell,

(4) carry carbon dioxide away from each cell, (5) carry hormones to the cells, and (6) carry antibodies and white blood cells to areas of infection. In many animals, capillaries connect the arteries and veins forming what is known as a closed circulatory system. In other forms, an artery may pump blood into a cavity known as a sinus. Veins then return the blood to the heart. This type is called an open circulatory system.

Coordination and communication is unnecessary to the one-celled forms, but higher forms need some system for coordinating activities. This may be done in two ways--the nervous system, a rapid means of coordination, or the endoctrine system, a slower method of coordination.

In the nervous system, specialized cells known as neurons conduct nerve impulses from one part of the body to another. The neurons, in lower forms, form a loose network of nerves known as a nerve net. Above this level, neurons combine to form nerves. Concentrations of nerve tissue are known as ganglia. Usually the ganglia are connected by a double nerve cord. The anterior ganglion is usually larger and may be referred to as the "brain". In Chordates, the nervous system consists of a brain, spinal cord, and numerous nerves.

The endoctrine system, composed of ductless glands (thyroid, pancreas, gonads, etc.), secretes hormones which are carried to various parts of the body by the bloodstream, where responses are brought about.

In order to continue the existence of a species, new individuals must be formed. This may be done either sexually or asexually. Asexual methods of reproduction include fission (protozoa), budding (hydra), and fragmentation (earthworm). Sexual reproduction is more common in the higher forms. In this type of reproduction, two sex cells (gametes) fuse to form a zygote which develops into a new individual. Hermorphrodites (earthworms, for example) contain both the ovaries and testes in the same individual. In most forms, the sexes are separate. In this case, some provision must be made for the union of the sperm and ovum. In some aquatic forms (clams), the sperm are discharged at random into the water and unite with an ovum by chance. In others (fish and frogs), sperms and ova are discharged simultaneously into the water, and a large per cent of the eggs are fertilized. In reptiles, birds, and mammals, a specialized organ in the male (penis) is used to transfer the sperm into the vagina of the female. After fertilization has taken place, in reptiles and birds, an egg (zygote plus reserve food) is discharged from the female and later hatches. In mammals, the zygote attaches itself to the wall of the uterus, and the embryonic development begins. Following the period of gestation, the young mammal is born.

OUTLINE OF CONTENT MATERIAL

- I. Economic Importance of Animals
    - A. Food production.
        - 1. Domestic animals.
        - 2. Wild animals.
        - 3. Fish.
    - B. Clothing production.
        - 1. Leather.
        - 2. Fur.
        - 3. Fabric.
            - a. Silk.
            - b. Wool.
    - C. Beasts of burden.
    - D. Medicine.
        - 1. Production of vaccines.
        - 2. Production of serum.
    - E. Research.
    - F. Recreation.
    - G. Companionship.

- II. Population Dynamics.
    - A. Examples (in background information).
    - B. Limiting factors of population.
        - 1. Reproductive potential.
        - 2. Environmental resistance.
    - C. Relationship of reproductive potential to environmental resistance.
        - 1. Examples.
        - 2. Prey.
        - 3. Predator.

- III. Inter-relationships in Nature
    - A. Food chains and food webs (see plant unit).
    - B. Symbiosis.
        - 1. Parasitism.
            - a. Host.
            - b. Parasite.
            - c. Vector.
        - 2. Commensalism.
        - 3. Mutualism.
    - C. Prey - predator.
        - 1. Definition.

    2. Harmful or beneficial.
    3. Control.
    4. Animal camouflage.
        a. Protective coloration.
        b. Protective resemblance.
        c. Countershading.
        d. Mimicry.

D. Exotics.
E. Scavengers.
F. Competition between species.
G. Agents of pollination.
H. Dissemination of seeds, spores, etc.
    1. By birds.
    2. By mammals.
    3. By insects.
I. Reactions to seasonal changes.
    1. Hibernation.
        a. Go below frost line.
        b. Den up or hole up.
    2. Estivation.
    3. Migration.
    4. Reproduction.
    5. Storage of food.
    6. Remain active.
J. Limiting factors of the environment.
    1. Food.
    2. Water.
    3. Temperature.
    4. Sunlight.
    5. Atmosphere (oxygen).
    6. Biotic factors.
    7. Cover (natural and man-made).
        a. Contour strips.
        b. Field hedges.
        c. Sod waterways.
        d. Diversion terraces.
        e. Field borders.
        f. Managed orchards.
        g. Evergreen plantations.
        h. Farm ponds.
        i. Standing crops.
        j. Trees.

IV. Man and Animal Populations

- A. Early utilization of animals in the United States.
  - 1. Food.
  - 2. Clothing.
  - 3. Furs.
    - a. Mountain men.
    - b. Fur-trading companies.
      - 1. Opening new territories.
  - 4. Market hunting.
    - a. Passenger pigeon, buffalo, and beaver.
    - b. Effect on Indians.
  - 5. Inland and coastal fishing and its effect on United States expansion.
- B. Early game laws and attempts to conserve game.
  - 1. 1721: First game law passed.
  - 2. 1878: Establishment of first state fish and game commissions.
    - a. California.
    - b. New Hampshire.
  - 3. 1908: President Theodore Roosevelt.
  - 4. 1916: Creation of National Park Service.
  - 5. 1929: Norbeck-Anderson Migratory Bird Conservation Act.
  - 6. Others.
- C. Constructive effects.
  - 1. Regional planning.
  - 2. Conservation farming (see units on soil and plants).
  - 3. Selective lumbering (see unit on plants).
  - 4. Fire control (see unit on plants).
  - 5. Wildlife management.
    - a. Stages.
      - 1. Laws passed when animal populations start decreasing.
      - 2. Formation of wildlife refuges for breeding areas.
      - 3. Predator control.
      - 4. Restocking program.
      - 5. Habitat improvement program.
    - b. Agencies.
      - 1. Pennsylvania Fish Commission.
        - a. Protection.
          - 1. Laws (limits, size regulations, and seasons).
          - 2. Fish wardens.
        - b. Restocking programs.
        - c. Management programs.
          - 1. Research.
            - a. Benner Spring Fish Research Station.
            - b. Linesville Fish Cultural Station.

        - d. Education programs.
            - 1. Fishing clinics.
            - 2. Others.
        - e. H. R. Stackhouse Fishery Conservation & Watercraft Safety School.
    - 2. Department of Forests & Waters.
        - a. State parks.
        - b. Recreational and educational areas.
    - 3. Pennsylvania Game Commission.
        - a. Protection.
            - 1. Laws (limits and regulations).
            - 2. Game protectors.
        - b. State game lands.
        - c. Farmer cooperation.
        - d. Game farms.
            - 1. Restocking programs.
            - 2. Propagation programs.
        - e. Management programs.
            - 1. Wildlife refuges.
            - 2. Food and cover.
            - 3. Research.
        - f. Education programs.
            - 1. Hunter safety.
            - 2. Others.
        - g. Ross Leffler Conservation School.
    - 4. Federal government.
        - a. National Fish & Wildlife Service.
        - b. Department of Agriculture.
    - 5. Societies.
        - a. Audubon.
        - b. Wilson.
        - c. Wildlife Management Institute.
        - d. National Wildlife Federation.
        - e. Wildlife Society.
    - 6. Colleges.
- D. Research.
- E. Farm game.
- F. Migratory waterfowl.

V. Animal Conservation in the United States
- A. Laws passed by state governments.
- B. Private groups which have influenced conservation.
    - 1. Audubon.

    2. Theodore Roosevelt's Boone & Crockett Club.
    3. Izaak Walton League.
    4. Others.
  C. Influence of the federal government.
    1. Fish & Wildlife Service.
    2. Progressive movement headed by Theodore Roosevelt.
    3. The New Deal.
  D. Wildlife resources - past, present, and future.

VI. Classification
  A. Animal diversity and taxonomy.
  B. Adaptation and evolutionary principles.
  C. Evolution.
  D. Number of phyla.
    1. Protozoa: one-celled animals.
      a. Sarcodinia.
        1. Locomotion by means of pseudopods.
        2. Example: Amoeba.
      b. Ciliata.
        1. Locomotion by means of cilia.
        2. Example: Paramecium.
      c. Flagellata.
        1. Locomotion by means of flagella.
        2. Example: Euglena.
      d. Sporozoa.
        1. No locomotion needed.
        2. Example: Plasmodium vivaz (causes malaria).
    2. Porifera.
      a. Characteristics.
        1. Multi-cellular; tissues present but no organs. .
        2. Organism perforated by numerous pores.
        3. Collared cells (choanocytes) present.
      b. Example: Sponges.
    3. Coelenterates.
      a. Characteristics.
        1. Radial symmetry.
        2. Incomplete digestive tracts.
        3. Diploblastic.
      b. Examples: Hydra, jellyfish, coral, and sea anemone.
    4. Platyhelminthes.
      a. Characteristics.
        1. Bilateral symmetry.
        2. Triploblastic.

        3. Incomplete digestive system.
    b. Examples: (Flatworms) planaria, flukes, and tapeworms.

5. Nemathelminthes.
    a. Characteristics.
        1. Bilateral symmetry.
        2. Triploblastic.
        3. Complete digestive system.
        4. No segmentation.
    b. Examples: (Roundworms) ascaria, hookworm, vinegar eel, and trichina worm.
6. Annelids.
    a. Characteristics.
        1. Segmented body.
        2. Bilateral symmetry.
        3. Complete digestive system.
        4. Body covered with a moist cuticle.
        5. Appendages present (setae).
    b. Examples: (Segmented worms) earthworm, leech, and sand worm.
7. Molluscs.
    a. Characteristics.
        1. Bilateral symmetry.
        2. Complete digestive system.
        3. No segmentation.
        4. Body enclosed by a "mantle" and usually a shell.
    b. Examples: (Shellfish) snail, clam, oyster, and squid.
8. Arthropods.
    a. Characteristics.
        1. Jointed appendages.
        2. Exoskeleton of chitin.
        3. Segmented.
        4. Bilateral symmetry.
        5. Complete digestive system.
    b. Sub-groups.
        1. Crustaceans.
            a. Characteristics.
                1. Two pair of antennae.
                2. Ten to nineteen pairs of appendages.
            b. Examples: Crab, crayfish, barnacle, and lobster.
        2. Centipedes.
            a. Characteristics.
                1. One pair of appendages per segment.
                2. Appendages relatively long.
                3. Fast-moving, carnivorous.

            - 4. Two body regions: head and body.
        - b. Example: Centipede.
    - 3. Millipedes.
        - a. Characterisitcs.
            - 1. Two pairs of appendages per segment.
            - 2. Appendages relatively short.
            - 3. Slow-moving, vegetarian or scavenger.
            - 4. Two body regions: head and body.
        - b. Example: Millipede.
    - 4. Arachnids.
        - a. Characteristics.
            - 1. No antennae.
            - 2. Four pairs of legs.
            - 3. Two body regions: head and cephalothorax.
        - b. Examples: Mites, ticks, and spiders.
    - 5. Insects.
        - a. Characteristics.
            - 1. One pair of antennae.
            - 2. Three pairs of legs.
            - 3. Frequently have wings.
            - 4. Three body regions: head, thorax, and abdomen.
            - 5. More species of insects than all other species of animals combined.
        - b. Examples: Bees, ants, wasps, fleas, and butterflies.
        - c. Harmful activities of insects.
            - 1. Immature stage - pupa or larval.
            - 2. Mature stage.
            - 3. Destruction of buildings and wood.
            - 4. Destruction of clothing and fabrics.
            - 5. Transmission of disease germs to animals and man.
            - 6. Destruction of grains, vegetables, and fruit.
            - 7. Annoy and injure by bites and stings.
        - d. Control of insects.
            - 1. Quarantine.
            - 2. Conservation of natural enemies.
            - 3. Environmental and biological control.
            - 4. Chemical control.
                - a. Stomach poisons.
                - b. Insecticides.
                - c. Fumigants.
                - d. Repellants.
- 9. Echinoderms.
    - a. Characteristics.

    1. Radial symmetry in adult stages.
    2. Body covered by spines or plates.
    3. Triploblastic.
    4. No segmentation.
  - b. Examples: Starfish, sea cucumber, and sea urchin.

10. Chordates.
  - a. Characteristics.
    1. Internal skeleton.
    2. Segmentation.
    3. Bilateral symmetry.
    4. A single tubular dorsal nerve cord.
  - b. Sub-groups.
    1. Fish (Pisces).
      - a. Groups.
        1. Cyclostome.
        2. Cartilaginous.
        3. Bony.
      - b. Characteristics.
        1. Cold-blooded.
        2. Breathe by means of gills.
        3. Scales usually present.
        4. Aquatic.
      - c. Habitats.
        1. Catadromous.
        2. Anadromous.
        3. Salt-water.
        4. Fresh-water.
      - d. Factors affecting distribution.
        1. Water temperature.
        2. Movements of water.
        3. Food supplies.
        4. Salt concentration.
        5. pH.
        6. Oxygen supply.
        7. Pollutants.
      - e. Common fishes of Pennsylvania.
        1. Warm-water.
          - a. Bass.
          - b. Pickerel.
          - c. Blue gill.
          - d. Carp.
          - e. Sucker.
          - f. Others.

        2. Cold-water.
            a. Trout (Brook, Brown, and Rainbow).
            b. Others.

2. Amphibians (Amphibia).
    a. Characteristics.
        1. Breathe by gills in larval state.
        2. Breathe by lungs or through skin as adults.
        3. No scales.
        4. Cold-blooded.
    b. Examples: Frogs, toads, and salamanders.
3. Reptiles (Reptilia).
    a. Characteristics.
        1. Cold-blooded.
        2. Breathe by means of lungs.
        3. Scales present.
    b. Examples: Snakes, turtles, lizards, and alligators.
    c. Snakes.
        1. Superstitions.
        2. Poisonous snakes in Pennsylvania.
            a. Rattlesnake.
            b. Copperhead.
        3. Treatment of snake bite.
4. Birds (Aves).
    a. Characteristics.
        1. Warm-blooded.
        2. Feathers present.
        3. Young hatch from an egg.
        4. Light-weight bones (air-filled).
    b. Examples: Robin, pheasant, and sparrow.
    c. Protection of birds.
        1. National Wildlife Refuge System.
        2. National and state parks.
        3. Laws to protect birds.
    d. Common birds of Pennsylvania.
        1. Protected.
        2. Non-protected.
        3. Regulated harvest.
    e. Bird migration.
        1. Migratory routes.
            a. Latitudinal.
            b. Altitudinal.
        2. Bird banding programs.

5. Mammals (Mammalia).
    a. Characteristics.
        1. Warm-blooded.
        2. Hair present.
        3. Mammary glands present.
        4. Diaphragm present.
    b. Sub-groups.
        1. Egg-laying: duckbilled platypus.
        2. Pouched: opossum.
        3. Toothless: armadillo.
        4. Insect-eating: moles.
        5. Flying: bats.
        6. Marine: whales.
        7. Flesh-eating: cats.
        8. Rodentlike: rabbits.
        9. Hoofed: horses.
        10. Trunk-nosed: elephant.
        11. Erect: monkey, ape, and man.
    c. Common mammals of Pennsylvania.

VII. Structure and Physiology of Animals
    A. Cell.
    B. Tissue.
    C. Organ.
    D. Systems.
        1. Needs of cells.
            a. Food.
            b. Oxygen.
            c. Waste removal.
            d. Transportation.
            e. Coordination.
            f. Communication.
            g. Support and protection.
            h. Movement.
        2. Systems furnishing needs.
            a. Digestive system.
            b. Respiratory system.
            c. Excretory system.
            d. Circulatory system.
            e. Nervous system.
            f. Endocrine system.
            g. Skeletal system.
            h. Muscular system.

i. Reproductive system.

VIII. Basic Principles

A. Wildlife is a renewable resource.

B. Game species should be regarded as a crop; excess populations should be harvested periodically.

C. Soil, water, plants, and animals are inter-related.

D. Animals are of great economic importance.

E. Each habitat has its own particular aggregation of species.

F. Animal distribution depends upon environmental factors.

G. In general, predators are beneficial.

H. In this country, game belongs to the state, not to the property owner.

I. Animal populations should not exceed the "carrying capacity" of the land.

J. The "carrying capacity" of the land may be increased by proper management. It may be decreased by overgrazing, fire, erosion, careless cultivation, etc.

K. Habitat destruction dooms those species adapted to the particular habitat involved.

LEARNING ACTIVITIES AND MATERIALS

I. Learning Activities
   A. Demonstrations.
      1. Secure several earthworms as a result of a field trip. Externally locate the following structures: (1) clitellium, (2) mouth, (3) anus, and (4) setae. Note the segmentation of the body.

         Using appropriate dissecting tools, cut through the dorsal surface of the body wall of one of the worms from the anterior end and through several segments beyond the clitellium. Pin back the body wall on each side. Point out the individual parts of the following systems: (1) digestive, (2) circulatory, (3) nervous, (4) excretory, and (5) reproductive.
      2. Repeat the above demonstration using such animals as: (1) frog, (2) perch, (3) white rat, (4) chicken, (5) crayfish, (6) clam, and (7) grasshopper.
      3. Secure a stethoscope and listen to the beating of the heart and the breathing of the lungs.
      4. Locate the pressure point at the base of the thumb. Using the tip of the index finger, count the number of heart beats per minute. Following ten minutes of brisk exercise, again count the number of heart beats per minute. Explain the difference.
      5. Start with the name of one animal on the center of the blackboard. On one side of this, write the names of animals and plants upon which it feeds. On the other side, write the names of animals which feed upon it. Join these names with lines. Repeat the process for each of the new names. This will illustrate a food chain and a food web.
      6. Secure a bird banding permit and operate a bird banding program. This should be done over a period of a few years. (Note: These permits are difficult to obtain.)
      7. For a given period of time--possibly a week in the spring, summer, fall, and winter--run a trap line to determine the fluctuation of the mice population in a given area. What are the reasons for these changes? Food? Temperature? Cover?
      8. For a project that will cover several years, select a woodlot. In the center of the woodlot, cut out the timber of an area of fifty to sixty feet in diameter. Before the timber is cut, make a complete survey of plants present. When the area has been cleared, keep complete records as to what and where plants first appear and what animal life is associated with each given plant. The same study can be done in an abandoned field. This will show the succession and the ecology of a specific area.
      9. Make an animal skull collection. Study the teeth to determine the food habits of each animal. A skull collection of mammals is very useful in taxonomy studies.

B. Field trips.
   1. Visit a fish hatchery (Benner Springs).
   2. Visit a fur farm, such as a mink ranch.
   3. Visit a game farm (Pennsylvania Game Commission).
   4. Make a field trip to a forest, meadow, pond, swamp, cave, etc. to look for insects, birds, mammals, reptiles, amphibians, invertebrates, etc. Return to the same habitat during the various seasons of the year to note the seasonal changes. Also note the relationship of species of plants to species of animals.
   5. Visit a snow-covered forest or meadow to interpret the story told by animal tracks in the snow. Note the number and kinds of tracks. Note the relationship of the animal activity in comparison to the cover. Do you find more tracks on the northern or southern side of a ridge? Why?
   6. Visit a museum to learn about animals of the past and animals of other areas.
   7. Visit a zoo to see live animals from other areas. Contrast the behavior of the animal in the zoo to its behavior in its natural environment.
   8. Visit a farm to see how domestic animals are cared for.
   9. Visit an old sawmill to look for snake eggs in the sawdust pile.
   10. Visit a strip mine or road cut to look for fossils.
   11. Take an early morning bird walk. Try to identify birds by their calls.
   12. Visit an aquarium to observe and study the characteristics of aquatic animals.
   13. Contact the local fish warden for a trip to a local fresh-water stream. This trip should include the study of the pH of the water, the hardness of the water, and aquatic life.
   14. Visit a farm pond to see how it is managed. How was it financed? Why?

C. Discussion.
   1. Discuss several possible explanations for bird migration.
   2. Discuss the factors which have led to the extinction of some of our animals today. Discuss possible steps which could be taken to prevent our rare animals from becoming extinct in the future.
   3. How might you encourage wildlife on a farm? In your backyard? On the school grounds?
   4. What should you do for snake bites?
   5. Do we have too many deer in Pennsylvania?
   6. What is meant by the "balance of nature"?
   7. What are the common fur bearers in your area?
   8. What animals are protected by law and why are they protected?
   9. What is the difference between "biological" and "artificial" control of insects?
   10. Which animals face extinction in the United States? Why?
   11. What is the value of wildlife to recreation?

12. What are the implications to our coastal fishing of increased fishing by foreign nations off our coast?
13. Why do we have game laws? Who is responsible for making these laws?
14. What are the common foods in the United States? In China? In Norway? In Egypt?
15. What are the various types of metamorphosis in insects?
16. What are protective adaptations?
17. Discuss the similarities and differences of animals found in dense woods, open woodlands, and on farmlands.

D. Bulletin board displays to illustrate:
1. The interdependence of man and animals.
2. The location of chief game animals and fish in Pennsylvania.
3. Beneficial insects and harmful insects.
4. How to make an insect collection.
5. How to make a bird feeder and a bird house.
6. Animals that live in a forest, pond, swamp, meadow, and an orchard.
7. How to take pictures of birds, animals, insects, etc.
8. How to make plaster casts of animal tracks.
9. Plaster casts or animal tracks of the area.
10. Safety first for hunters and fishermen.
11. How to increase the game animals on a farm.
12. Common parasites of man and of domestic animals.

E. Student activities and projects.
1. Break open an old log and observe the animal life found in it.
2. Make an insect collection.
3. Write a paper on the slaughter of the buffalo or the passenger pigeon.
4. Write a paper on the contribution of the following to wildlife: Agassiz, Thoreau, Walton, and Seton.
5. Build and install a bird feeder. Keep a record of all species visiting the feeder and the time of their visits.
6. Collect cocoons and observe the emergence of the moths.
7. Set up and observe a terrarium.
8. Build and stock a formicarium with ants.
9. Collect frog eggs and observe the developing tadpoles.
10. Install an observation hive for keeping bees in the classroom.
11. Conduct a game and wildlife census of an area near your school. Take part in the annual Christmas bird census.
12. Prepare a report on one problem in your community, such as: insect pests, rat and mice control, sewage disposal, etc.
13. Survey the school ground to find plant and animal relationships.
14. Make a series of illustrated maps of your community showing: (1) the original condition of your community, the land forms, rivers and streams, location of forests, and the first roads and settlements and

(2) how this has changed. Show by a second map.

15. Build a question and answer board about wildlife. Use such things as identification or placing animals in correct habitat.
16. Construct and maintain wildlife game feeders in local forest lands. Contact the Pennsylvania Game Commission for permission and details.
17. Record the species and number of animals killed on a particular stretch of highway for several weeks.
18. Prepare drawings showing proper uses of various types of stream improvement devices.

II. Learning Materials

A. Audio-visual materials.

1. See list of sources at the end of the guide.

B. Books and pamphlets.

1. Ayres, R. V., "Food", Science Journal, October, 1967.
2. Bates, Marston, Animal Worlds, Random House, 1963.
3. Bates, M., The Forest and the Sea, Signet Science Library, 1964.
4. Bats, U. S. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife, Department of the Interior, Washington, D. C. 20240.
5. Booth, Ernest S., How to Know the Mammals, William C. Brown Company, Bubuque, Iowa, 1961.
6. Brown, Harrison, The Challenge of Man's Future, Viking Press, 1953.
7. Cahalane, Victor H., Mammals of North America, The MacMillan Company, New York, 1961.
8. Collins, Henry Hill Jr., Complete Field Guide to American Wildlife, Harper and Row, New York, 1959.
9. Cole, LaMont C., "The Impending Emergence of Ecological Thought", Bioscience, July, 1964.
10. Commercial Fisheries of the United States, Fish and Wildlife Service, U. S. Department of the Interior, Washington, D. C.
11. Comstock, Anna Botsford, Handbook of Nature Study, Comstock Publishing Associates, Ithaca, New York, 1959.
12. Conservation Living in Farming with Land, Agricultural and Home Economic Extension Service, The Pennsylvania State University, V. Ed. 5-192.
13. Darling, F. Fraser and Milton, J. P. (editors), Future Environments of North America, The Natural History Press, 1966.
14. Deer Management in Pennsylvania, College of Agriculture Extension Service, The Pennsylvania State University, V. Ed. 4-15.
15. Devoe, Alan, Speaking of Animals, Creative Age Press, 1947.
16. Eddy, Samuel, How to Know the Freshwater Fishes, William C. Brown Company, Dubuque, Iowa, 1957.
17. Fish Culture in Pennsylvania, Pennsylvania Fish Commission,

Commonwealth of Pennsylvania, February, 1968.

18. Gabrielson, Ira N., Wildlife Conservation, The MacMillan Company, New York.
19. Gabrielson, Ira N., Wildlife Management, The MacMillan Company, New York.
20. Goddard, M. K., Conservation of Natural Resources in Pennsylvania, (unpublished), 1963.
21. Hanson, E. D., Animal Diversity, Prentice-Hall, Inc., 1964.
22. Herfindahl, O. C. and Kneese, A. V., Quality of the Environment: An Economic Approach to Some Problems in Using Land, Water, and Air, The Johns Hopkins Press, 1965.
23. Landsberg, H. H., Fischman, L. L., and Fisher, J. L., Resources in America's Future, The Johns Hopkins Press, 1963.
24. Lane-Petter, W. (editors), Animals for Research, Academic Press, 1963.
25. Lemmon, Robert S., All About Strange Beasts of the Present, Random House, New York, 1957.
26. McClung, Robert M., All About Animals and Their Young, Random House, New York, 1956.
27. Melady, John Hayes, The Nature Dictionary, World Publishing Company, New York, 1950.
28. Miller, Jack and Buss, Keen, The Age and Growth of the Fishes in Pennsylvania, Public Relations Division, Pennsylvania Fish Commission.
29. Milum, V. G., Honey Production, University of Illinois, College of Agriculture, January, 1960.
30. National Wildlife Refuges, U. S. Department of the Interior, Fish and Wildlife Service, (for sale by the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20240).
31. Penney, Roy, Vanishing Wildlife, Budd, Mead & Company, New York.
32. Peterson, Roger Tony, A Field Guide to the Birds, Houghton Mifflin Company, Boston, 1960.
33. Protecting Our Endangered Birds, Fish and Wildlife Service, U. S. Department of the Interior, Washington, D. C. 20240.
34. Reavley, William L., Wildlife of Forests and Rangelands, National Wildlife Federation, Washington, D. C. 20036, 1964.
35. Romer, A. S., The Vertebrate Body, Yale University Press, 1960.
36. Rounds, Glenn, Wildlife at Your Doorstep, Prentice-Hall, 1958.
37. Seasonal Fluctuations in Field Consumption of the White-tailed Deer, College of Agriculture, The Pennsylvania State University, Progress Report 262.
38. Simpson, G. G., The Meaning of Evolution, Yale University Press, 1949.
39. Snakes, Fish and Wildlife Service, U. S. Department of the Interior, Washington, D. C.
40. Zim, Herbert S. and Cottam, Clarence, Insects - A Guide to Familiar American Insects, Golden Press, New York, 1962.

HUMAN

RESOURCES

BACKGROUND INFORMATION

EARLY MAN

Reconstruction of the evolutionary history of any organism may be approached in the historical, comparative, or analytical method of study. The historical method is the only one that provides us with direct evidence, in the form of fossil remains, from the past. However, the fossil record is very incomplete and is dependent on the accidents of preservation.

To interpret the fossil story we must put flesh on the bones, judge habits from bones, and thus deduce the way of life of the fossil. With man, we have tools as well as bones to be considered as fossil records of human habits. Still the record is fragmentary, for the wooden instruments, the skins, and the fibers that were used by early man have rarely been preserved.

In order to understand man's place in the scheme of events, it is important to know something of the order (Primates) to which he belongs.

Zoologists now include in the Primate order not only apes, monkeys, and lemurs, but also tree shrews, loris, galagos, and tarsiers (general characteristics of this group are listed in the outline).

The number of living primates, compared with other mammal orders, is not large. Almost all of them are tropical, and many of them are rare and little known. But the literature about them is enormous, and the opinions about how they should be classified are many. Since man is a primate, the classification of this order tends to get out of perspective (Primate classification is shown in the outline).

The Prosimians include a rather miscellaneous group of animals that shed considerable light on the evolution of the higher primates. The fossil record of this group is the poorest of any mammal order; apparently, primates have always been tropical and largely forest animals with habits that would only rarely lead to fossilization.

One theory is that the primates developed from the insectivores very early in mammalian evolution. One living group, the tree shrews, shows characteristics that lead some students to class them with the insectivores. Others place them with the primates. The tupaiidae are small, squirrel-like arboreal animals that differ from other primates in having claws rather than nails, but that also have other characteristics similar to those of the lemurs.

The lemurs are mostly arboreal, though many of them forage on the ground with quadrupedal locomotions. The majority are omnivorous in eating habits. They are said generally to be social, moving in groups of ten to twenty individuals with occasional fights among individuals.

Two other prosimian groups are generally recognized--the lorises and the tarsiers. They are small, furry animals and most species are nocturnal; therefore, direct observation of their behavior is difficult, and not much is known about them.

The monkeys of the New World tropics and those of the Old World are only distantly related. It is believed that they have had separate evolutionary histories for a very long time. It seems likely that the New World monkeys evolved from tarsieroid or lemuroid stock that reached America in the Eocene or Paleocene, though the scarcity of fossils makes it difficult to be sure of the history of the group.

Some differences between the Old World and New World monkeys are listed in the outline. The Old World monkeys, in the classification of G. G. Simpson, are placed in sixteen genera divided among two subfamilies. The Ceropithecinae includes the baboons, macaques, and their relatives--many of them ground-living and all except the macaques purely African. The Colobinae family is purely arboreal and includes five Oriental genera and one African genus, Colobus.

The best known of the Old World monkeys is the Indian macaque or rhesus monkey. Due to their abundance and the fact that they can be bred fairly easily in captivity, they are used extensively in research programs. They are clearly social, living in bands that may include as many as 150 individuals. Both rhesus monkeys and baboons apparently show territorial behavior and in captivity exhibit a dominance hierarchy (peck-order), with one adult male dominant. The various species of gibbons of Southeast Asia are the smallest of the apes (three feet tall). They are the best arboreal acrobats with long arms that reach the ground when the animal stands erect. The gibbon lives in monogamous families consisting of an adult male and female with one or more young. Each family lives within a definite territory and when two families approach the borders of their territories, unfriendly and aggressive behavior often occurs--though actual fighting rarely occurs.

Only one species of the Orang-utan exists and is found in Sumatra and Borneo. It is more arboreal than the gorilla or chimpanzee. The females average 81 pounds and the males, 165 pounds. The males are essentially solitary though groups of two or three females with their young live together.

There are two forms of Gorilla in Africa, a mountain type in the vicinity of Lake Edward and Lake Kivu and a lowland form in the deep rain forest of the Cameroons and the Congo. Both are big animals--the males weighing as much as 450 pounds and standing six feet high or more; the females are somewhat smaller.

Gorillas look fierce, and the males, at least, will defend themselves vigorously if attacked. George B. Schaller found that in their home forests they were placid, peaceable animals, secure from any enemy except armed men and possibly leopards. They live in social groups including two to thirty individuals. One adult male is the leader, and there is a clear dominance hierarchy among the males; but Schaller observed no fighting except, an occasional squabble among the females.

Each gorilla group tends to stay within a particular area--a home range covering ten to fifteen square miles. They are not, however, territorial in the strict sense of the word since the range of a particular group is not defended against intrusion by outsiders. Several groups, in fact, may range over the same area and pass the night within a few hundred yards of each other peaceably. Members of different groups do not freely intermingle. The behavior of these animals sheds little light on the possible origin of the damaging intergroup conflict that has so long characterized the human species. Gorillas and other apes are vegetarian, while the evidence indicates that the human line has been predatory for a very long time. Perhaps this is the basis of human ferocity.

There are several varieties or possible species of chimpanzees, and all are from tropical Africa and are classified in the genus, Pan.

The behavior of the two apes differs in many respects. The lighter-weight chimpanzees are much more arboreal in their habits than are the gorillas. The chimpanzees also have a much looser social organization.

Several chimpanzees have been raised in households where they were given the same care and attention as human children. Their performance under these circumstances is remarkable; they learn to manipulate household gadgets and to carry out many kinds of complicated actions. They outstrip human children up to the time when communication through language becomes dominant. The apes learn to respond to a wide variety of words, but most efforts to try to make them speak have failed. This failure apparently is not only a consequence of anatomy. The infant apes just do not go through the sound-imitating and sound-producing stage that characterizes every human child.

When Darwin published the Descent of Man in 1871, he built his case for human evolution entirely on evidence from living men and living primates, and he thought that "the great break in the organic chain" between apes and man might never be bridged because of the imperfect nature of the fossil record. His book did, however, create the climate of opinion in which the importance of finding "missing links" became widely recognized, and people became alert to the possible significance of any old human bones they might come across.

Actually, the first of the important fossils was found in 1856 in one of the grottoes along the little vale called Neanderthal near Dusseldorf, Germany.

In 1894, Eugene Dubois found some remains of a man now known as Java Man and described by Dubois as Pithecanthropus erectus.

In the late 1920's and 1930's, a series of man-like fossils were found in cave deposits near Peking, China. These were the remains of what has come to be called Peking Man, Sinanthropus. In subsequent years, a variety of hominid fossils have been discovered, mostly in Africa, and we are gradually recovering more material on ancient man than Darwin had ever hoped for. These do not, however, form a neat chain of links leading from ancient man to modern man. They cannot be arranged in any single sequence, and it appears that a considerable variety of man-like animals lived at different times and places in the Pleistocene. One of these--the kind we know today--eventually won out.

In 1924, Raymond Dart classified a skull as Australopithecus africanus. Convinced that he had a "missing link", he received relatively little support from the scientific world for most anthropologists thought he had some sort of fossil ape, remote from the human line.

In 1936, Robert Broom found another Australopithecine skull and classified it as Australopithecus transvaalensis. Discoveries have continued, and now fossil fragments of some dozens of Australopithecine individuals have been recovered from South African localities. In 1959, L. S. B. Leakey discovered another Australopithecine fossil in Tanganyika which he named Zinjanthropus.

From the structure of the pelvis and the way the skull is attached to the spinal column, we know that the Australopithecines were almost fully bipedal and walked upright. They were rather small, averaging five feet tall, but they had heavy jaws and unusually large teeth, especially the molars and premolars. As far as physical structure is concerned, they have been called men from the neck down and apes from the neck up. Their cranial capacity was not much more than that of a chimpanzee; the normal chimpanzee range is about 350 to 450 c.c., that of Australopithecines 450 to 550 c.c., compared with 1200 to 1500 c.c. for modern man.

We have learned much about their way of life from careful excavations in the transvaal caves and from Leakey's studies in Tanganyika. Bones associated with the hominid fossils reveal that they hunted many kinds of animals, including baboons and antelope, and it is hard to imagine this kind of hunting except by well-coordinated, social groups. Leakey's Tanganyika man, the earliest of them all, clearly used pebble tools; but no stone tools have been found in the somewhat later South African cave deposits. Raymond Dart, however, was convinced that many of the bones found in the caves were shaped for use as tools and that the Australopithecine way of life was based on the use of bones, teeth, and horns. Whether they used fire or not cannot be determined. Nor do we know how developed was their vocal communication system. The nature of some of the bone fractures indicates that they had already acquired the very human habit of occasionally killing each other. If not men, they were at least well on the way to becoming men.

There is ample evidence in humans that the most different-looking individuals from the most remotely separated parts of the world can interbreed and produce fertile offspring. The differences, then, are at the subspecific rather than at the specific level.

The differences in appearance among men are considerable. There is a great variation in size, from the tall peoples of northern Europe to the pygmies of the Congo forest. Skin color ranges from shiny black to very pale. Large differences also exist in the texture and distribution of hair on the body, in the shape of the skull, and in the shape of soft parts like the nose and lips. No species of wild animal shows anything like this range of variation. The only species with comparable variation are the domesticated ones--dogs, swine, poultry, etc.--which leads some to believe that man is a self-domesticated animal.

Human variation is basically geographical. Mongoloid peoples inhabit eastern Asia, Negroid peoples, Africa, and Caucasoid peoples, Europe. The geographcial pattern has been greatly distributed by the large migrations of modern times, but it is still apparent. No wild animal is as widely distributed over the earth as man, but land animals very commonly show geographical variation within their ranges; and there is no reason to suppose that human variation differs in principle from that of other animals.

On a continent, a gradual change in the appearance of a species will sometimes occur as one moves from north to south or east to west; these changes may be more abrupt so that a series of different populations can be recognized with narrow transition zones between them. The first case is said to constitute a cline; the second a rassenkreis, or series of subspecies.

This geographical variation is easily understood in terms of genetic theory. Since a new mutation can only spread through the parts of a population that are in contact when populations are separated by geographical barriers, they tend to follow distinct evolutionary histories and in time will become so different that even if they did come together again, they would not fuse for they would have evolved into distinct species. This being the case, why hasn't man evolved into more than one species?

It looks as though man's tendency to collect in discrete and separate groups has been counterbalanced, all through history, by his desire--and ability--to move. Modern methods of communication and travel have brought all human populations into contact with each other to some degree, and the sort of isolation that could result in species formation is now clearly impossible. In fact, racial differences are tending to diminish today as large-scale shifts in population increase. It may be that in time, geographical variation in human physical appearance will disappear entirely.

As mentioned before, a number of distinct hominid types lived in the Old World tropics and subtropics during the early and middle parts of the Pleistocene period. It is difficult to be sure about the biological relations among these types.

However, of this variety of types only one, Homo sapiens, survived. Wherever sapiens started--subtropical Africa seems the most likely--he probably exterminated other hominid types as he encountered them. We can glimpse at this process in Europe, where Neanderthal man disappeared rather suddenly to be replaced by Cro-magnon man (a true sapiens), so that one can presume that the Neanderthal type was exterminated by the newcomers. Sapiens certainly spread widely and (in geological perspective) rapidly. He reached North America about 35,000 years ago, probably via the Bering Strait, and in a few thousand years inhabited both American continents. He must have gotten as far as Australia a very long time ago and then remained there in almost complete isolation.

Thus, Homo sapiens--we may conclude--has been scattered over the earth long enough for subspeciation to start, but the various populations have not been separated long enough and complete enough for different biological species to form.

There is no general agreement about the classification of human racial types. For our purposes, however, we can divide men into the races listed in the outline. Most anthropologists consider the American Indian to be a Mongoloid type, but it is sometimes useful to separate the two.

When we try to formulate a scientific definition of man, we tend to use cultural rather than physical or behavioral terms. We say that man is peculiar because he has language (has developed symbols that make abstract thought possible) or because he makes tools or because he uses fire.

We have no way of knowing whether the kinds of man represented by the earliest fossils could talk or not. The languages of living men all seem to be about equally complex--equally remote from the signal cries of other animals. Some living peoples, such as the Australian Aborigines, have simple material cultures; others, Europeans for instance, have complex cultures, but we cannot show any relation between the evolution of material cultures and the evolution of language.

Language does not leave artifacts, at least not until it has become written. We do find fossil tools, which give us clues to the evolution of culture. Tool-making and tool-using is not unique to man. Man's uniqueness is in the making of tools in accord with a pre-determined plan or pattern. Stones that were obviously shaped for some particular purpose by chipping occur in deposits that date from early in the Pleistocene period. Animals with this essential human characteristic have existed for several hundred thousand years.

The period when man first began to use fire is more difficult to determine than when he began to make tools. There is clear evidence of hearths in the caves of the Peking Man that are thought to date from the middle of the Pleistocene. However, it is more convenient to use tools, rather than fire or language, for drawing the line between man and not-man.

Man, with his culture, has learned to adapt to the most diverse climates and habitats and, as a result, has spread all over the world. He has drastically altered the landscape of large parts of the earth.

Wallace, with his years of living intimately with primitive peoples, came to feel that they were just as intelligent as he or any European and that although these people had many different cultures and ways of life, their potentialities were about the same as ours. The gap between all men and any ape is enormous. Wallace could not see how this gap could have been bridged by the process of natural selection. Finally, he came to the conclusion that the principle of natural selection which Darwin and he had discovered could not apply to human evolutions; that man must be an exception to the orderly operation of biological laws. Darwin, on the other hand, continued to believe that man was a natural phenomenon and that his development was in accordance with natural laws.

Most anthropologists and biologists today consider Wallace to have been right in his view that human potential is essentially the same everywhere, despite man's cultural diversity, and Darwin to have been right in that we must find explanations in terms of natural laws. We can reconcile their differences in terms of the distinction between capability and achievement and in terms of what might be called preadaptation.

We now know that an Eskimo or an African tribesman, properly trained, can fly an airplane as well as anybody else and with proper materials and knowledge, he could presumably make one, too. We have no evidence of biological evolution in man since the days of Cro-magnon man. Cro-magnon man could have made and flown an airplane if his culture had reached that evolutionary stage.

If we reverse this problem, we can perhaps understand it better. When modern archaeologists have set themselves the task of learning to chip and shape stone tools, after the fashion of the men of the later Stone Age, they have found that it is not easy and that it takes a highly educated scientist a long time to learn to do a decent job. The coordination of hand and eye; the care and foresight required for shaping a simple stone tool are essentially the same skills required to manufacture and manipulate modern gadgets of our civilization. The shift in capability that led to all our vaunted accomplishments started way back with some Australopithecine-like, rather small-brained primate who embarked on a career of tool-making, teaching, and learning and began accumulating the know-how and tradition, the extrasomatic inheritance, that underline cultural evolution.

MODERN MAN

The health, education, skills, and attitudes of the people themselves represent a major factor in the strength and productive capacity of a nation. It is quality, not quantity, that is crucial. In fact, it is possible that a large number of people might be a handicap rather than an advantage to a nation.

The total world population of humans has been increasing at an accelerating rate since the beginning of recorded history. It is estimated that at the present time we are adding 60,000,000 more persons each year to the total world population. This is an increase of approximately two persons per second. If this trend continues, we can expect the human population to just about double every forty years. At this rate, within one thousand years, the weight of the people of the earth would just about equal the weight of the planet.

The areas of the world having the greatest density of population are Japan, eastern Asia, India, England and northern Europe, northeastern United States, and Java (see charts in outline for more population figures).

In general, human populations are subject to the same natural laws that govern animal populations (see unit on animals); that is, predators, disease, and starvation. However, to a certain extent man has learned how to alter both the reproductive potential and the environmental resistance to his own advantage. In the more advanced (or should we say sophisticated) societies, the use of contraceptives (especially "the pill") has drastically reduced the number of unwanted pregnancies. Reproductive potential, which is defined as the maximum possible rate of reproduction in humans, now becomes "fertility", implying a certain degree of control over pregnancies.

Environmental resistance has also been altered by modern science and technology to the extent that average life span has increased from approximately twenty years for the cave man to seventy years today. Thus, environmental resistance should more properly be referred to as "mortality", and the population equation for humans can be written as follows:

$$\text{Human Population} = \frac{\text{Fertility (birth rate)}}{\text{Mortality (death rate)}}$$

One hundred thirty-six years ago, Thomas Malthus of England stated: "Uninhibited human populations increase in a geometric progression in such a way that a population will double every twenty-five years. Food supplies increase in an arithmetic progression." If this is true, according to Malthus, a given population with an adequate food supply will, unless preventive measures are applied, increase faster than the available food until such time as the inevitable malnutrition and starvation curb the rate of increase.

The present population of England is five times what it was at the time of Malthus. Does this mean he was incorrect? Not necessarily; science and technology have increased the productivity of agriculture and made it possible to transport food supplies from areas of production to urban centers thousands of miles away.

In many countries, social mores and religious objections are slowly evolving to the point where contraceptives may be accepted. Ignorance and poverty, however, present a different problem. Governmental help on a national and international level is needed before real progress can be made. Eventually, we will have to face the predictions of Malthus because the world is of finite size, and there are limits to the food which it can produce and thus the population which it can support. It is estimated that someone dies of starvation every 8.6 seconds. We can either take steps ourselves to limit the world's population at a level that will permit individuals to enjoy an adequate standard of living, or we can permit nature to limit the level of the population with malnutrition and starvation becoming the fate of many persons.

It should be noted that some countries (Sweden, Ireland, and Switzerland) have achieved population stability; but in the world as a whole, the average annual increase is 1.7%. A few countries (the United States, Canada, and Australia) have the means of supporting more people than they now have, but many nations have already reached the point where the present food supply is not adequate for their present population.

Hungry people are restless people. If a stable and just world peace is to be achieved, this problem must be solved.

Infant mortality, a major factor several centuries ago, has been reduced to such a point that it is now of minor importance in Europe and North America. The control of infectious diseases has made this change possible.

One of the chief factors in the productive capacity of a nation is the education and skills of the masses of the people. There are several problems in our educational system that must be remedied if we are to realize the full potential of our educational system. Some of the problems are:

1. Rural schools frequently lack the modern facilities found in urban schools.
2. The southern and midwestern schools usually are less well-equipped than those in the northeastern and Pacific Coast areas.
3. In some areas, certain racial groups (Mexican, Negro, Puerto Rican, and Indian) have been "short-changed" as far as educational facilities are concerned. No progressive nation can afford to neglect the education of any group of people because of race, religion, sex, or politics.

4. Vocational training for non-college students should be made available to all who can profit from it.
5. Additional facilities for advanced study are needed.

Education is the key to making man more effective and productive. The United States has stressed compulsory education for well over seventy years. As a result, we have become one of the most literate nations in the world. For many years, a high school education was the key to success. Now, for most of the population, it is simply a step on the way to further education. In many instances, four years of college no longer suffice. We are concerned with graduate schools in all areas of education. The United States has also started other educational programs to try to meet the needs of all citizens. Vocational-technical schools, community colleges, adult education, the Job Corps, Head Start, and Upward Bound are examples of the new programs. We no longer need armies of unskilled workers. This group of people must be trained by our educational system to become a useful segment of society.

Public health is another area vital to the protection of human resources. We have minimized the danger of epidemics among our population with immunization and improved medical facilities.

Great strides have been made in the area of industrial accidents. Employers have taken a more enlightened view of working conditions. Unions, insurance companies, workmen's compensation, and government at all levels have enforced regulations to safeguard human life. Safety engineers and safety campaigns are conducted by most industrial enterprises. Rigid physical and mental examinations are administered to candidates for employment by most major businesses. Business has been forced to install safety devices, allow rest periods, shorten hours, and furnish facilities for relaxation.

The increased cost of medical care presents a real problem to many people. Medicare and insurance programs are only partial answers (not all people have such protection). Inflation has accentuated what was already a serious problem. Many people can ill afford the medical or dental care which would prolong their period of usefulness to society.

However, we are still fighting problems of undernourished, poorly housed, and poorly clothed people, not only in our urban ghettos, but also in many rural areas as well. These conditions tend to perpetuate among certain parts of our population from one generation to another. This, essentially, is what our racial problem is about in this country.

For example, the life expectancy of a Negro is seven years less than for a white person. Negro women of child-bearing age have a mortality rate two to three times that of white women of the same age.

The length of the working day is another area in which we have attempted to help preserve our human resources. Man was used and abused as he was thrown into the vortex of the Industrial Revolution. Only with improved technology and enlightened social thinking has man been able to move to a position of having to worry about such things as retirement and leisure time.

Labor-intensive agriculture and industry have been replaced by technology which enable one man to produce what it once took a hundred men to produce. Thus, man's energy has been put to a much higher use. We have recently occupied our thinking with the consequences and problems of automation. Our social thinking has lagged woefully in comparison with our scientific and technological revolution.

However, some progress is being made. We no longer speak much about the forty-hour week. Labor and management bargain for extended vacations and shorter work weeks. Since 1900, the working hours have been cut in half. This gives man more time for recreation and leisure and creates new problems of finding ways to use leisure time and early retirement more productively.

Closely linked with physical health is mental health. The fast pace of our way of life in this country contains the seeds of tension. We have just begun to try to combat this condition. Society should supply opportunities for good physical, mental, and spiritual development. Social health in a nation is directly linked with crime, juvenile delinquency, and disregard for the law.

Recreation is essential to humans, and the wise use of leisure time is critical to a nation whose people have more and more free time. It is intimately related with all other resources. Streams and forests, if properly cared for, enable men to hunt and fish. They provide areas for camping, hiking, or just looking.

We have had a constant movement of people to urban areas. Parks, camping grounds, game refuges, and public hunting and fishing areas must be provided fairly close to cities. There has been great activity both public and private to provide these facilities. Greater strides must be made. National and state parks and facilities must be increased. John Stuart Mill, a famous economist, made the first correlations between the amount of money spent for recreation and the ills of society.

In order to be happy and content, most people need to feel that they are making a useful contribution to society. This is as essential for an older person as for anyone else. Many industries retire employees as soon as they reach age sixty or sixty-five. For jobs requiring physical strength and stamina, this might be reasonable; but in other positions this is a questionable procedure. Some industries put a worker on a part-time job when he reaches a certain age. This policy should be tried in many other areas. If this is not possible, then vocational retraining should be optional for older workers.

OUTLINE OF CONTENT MATERIAL

I. Early Man
  A. Study of early man.
    1. Historical.
    2. Comparative.
    3. Analytical.
  B. Classification of Primates.
      Order - Primates.
        Suborder - Prosimii.
          Infraorder - Lemuriformes.
            Superfamily - Tripaiordea.
              Family - Tripaiidae (tree shrews).
            Superfamily - Lemuroides.
              Family - Lemuridae (lemurs).
              Family - Indridae (indris).
            Superfamily - Daubentonioidea.
              Family - Daubentoniidae (aye-ayes).
          Infraorder - Lorisiformes.
              Family - Lorisidae (lorises, galagos).
          Infraorder - Tarsiiformes.
              Family - Tarsiidae (tarsiers).
    1. General characteristics of Primates.
      a. Hands and feet adapted for climbing.
      b. Clavicle or collar-bone present.
      c. Digits are freely mobile.
      d. Fingers and toes have flattened nails instead of claws.
        Suborder - Anthropordea.
            Superfamily - Ceboidea.
              Family - Cebidae (New World monkeys).
              Family - Callithricidae (marmosets).
            Superfamily - Cercopithricidae.
              Family - Colobidae (Old World monkey, baboons).
    2. Comparison of Old World and New World monkeys.
      a. New World monkeys.
        1. Platyrrhine or "flat-nosed".
        2. Tail present (many prehensile).
        3. No ishial callosites.
        4. No cheek pouches.
      b. Old World monkeys.
        1. Catarrhine (segmented nose).
        2. No prehensile tail.

        3. Ishial callosites.
        4. Cheek pouches present.
            Superfamily - Hominoidea.
                Family - Pongidae (apes).
                Family - Hominidae (fossil, living men).

C. Early types.
    1. Neanderthal man.
    2. *Pithecanthropus erectus* (Java Man).
    3. *Sinanthropus* (Peking Man).
    4. *Australopithecus*.
        a. *Africanus*.
        b. *Transvaalensis*.
        c. *Zinjanthropus boisei*.
        } Paranthropus

D. Varieties of men.
    1. Different physical features.
    2. Geographical variation.
        a. Cline.
        b. Rassenkreis.
    3. *Homo sapiens*.

E. Human races.
    1. Meaning of race.
    2. Types.
        a. American Indian.
        b. Australian.
        c. Caucasoid.
        d. Mongoloid.
        e. Negroid.

F. Culture characteristics.
    1. Communication.
    2. Material culture.
        a. Tools.
        b. Fire.
    3. Capability and achievement.
        a. Darwin.
        b. Wallace.
        c. Present thinking.

II. Modern Man
    A. What makes a nation great?
        1. Type of government.
        2. Business organization and management.
        3. Abundant natural resources.
        4. Capital investments.

5. People.

B. Inventory of world's population.

1. Estimated world population.

Year	Population
Beginning of Christian era	350 million
1200	500 million
1800	1 billion
1900	2 billion
1950	2.6 billion
1955	2.8 billion
1960	3.01 billion
1965	3.29 billion
1966	3.35 billion
1967	3.41 billion

2. Estimated population of selected nations (1965).

Nation	Population
China	700,000,000
India	500,000,000
Russia	235,000,000
United States	198,000,000
Indonesia	107,000,000
Pakistan	105,000,000
Japan	100,000,000
All Others	1,348,000,000

3. States with a population exceeding 10,000,000 (1965).

State	Population
California	19,090,000
New York	18,300,000
Pennsylvania	11,620,000
Texas	10,810,000
Illinois	10,800,000
Ohio	10,350,000

4. The ten largest cities of the world (1965).

City	Population
Tokyo	11,005,000
New York	8,025,700
London	7,948,800
Moscow	6,366,000
Bombay	4,653,700
Rio De Janerio	4,102,000
Peking	4,000,000
Buenos Aires	3,876,000
Chicago	3,543,000
Cairo	3,518,200

C. Human population dynamics.
  1. Reproductive potential.
  2. Environmental resistance.
  3. Genetic selection.
  4. Developmental adaptation.
  5. Thomas Malthus.

D. Population problems.
  1. Population explosion.
    a. Causes.
      1. Improved medicine.
      2. Improved sanitation.
      3. Improved nutrition.
      4. Shorter working hours.
      5. Decreased infant mortality rate (in some areas).
      6. Increased longevity (in some areas).
      7. Decreased early juvenile mortality.
    b. Dangers.
      1. Lack of space.
      2. Lack of food.
      3. Lack of proper education.
    c. Remedies.
      1. Curb population growth.
        a. Birth control.
          1. Restraint.
          2. Abortion.
          3. Contraceptives.
        b. Infanticide.
        c. War.
        d. Emigrate to other planets (remote possibility).
      2. Increase the food supply.
      3. Bring more land under cultivation.
      4. Use resources of the sea.
      5. Increase yields per acre.
    d. Problems associated with population controls.
      1. Social mores.
      2. Religious objections.
      3. Ignorance and poverty.
  2. Infant mortality (in underdeveloped countries).
  3. Education and training.
  4. Health and safety programs.
  5. Wise use of leisure time.
  6. Effective use of manpower.
  7. Productive old age.

LEARNING ACTIVITIES AND MATERIALS

I. Learning Activities
  A. Demonstrations.
    1. Conduct life-saving and safety demonstrations.
    2. Place mice in a cage so that they are crowded (lack of space) but give them ample food, water, nesting material, etc. Do the same to another group but do not crowd them. Compare the results. The crowded mice should become nervous, lose weight, indulge in physical combat, and even cannibalism. How does this relate to our "population explosion"?
    3. Arrange for an exhibit of skulls or models of the various "men" discussed in the outline. Discuss the possible evolution.
    4. Demonstrate various safe laboratory techniques (how to handle acids, bases, test tubes, etc.).
    5. Demonstrate various first-aid procedures in relation to accidents that might happen in the laboratory or at home.
  B. Field trips.
    1. To a truck garden farm to see how our food is grown.
    2. To a supermarket to see how our food is retailed.
    3. To a county, nursing, or convalescent home to see how some of our senior citizens live.
    4. To Mine Safety Appliances in Pittsburgh.
    5. To the U. S. Bureau of Mines in Pittsburgh.
    6. To a nearby industrial plant to observe their safety program in action.
    7. To a coal mine to observe rock-dusting and other efforts to reduce dust.
    8. To an area vocational-technical school.
    9. To a state mental hospital.
  C. Discussion.
    1. Are human resources more valuable than other resources?
    2. What factors are responsible for the greatest waste of human resources?
    3. How does recreation benefit human beings?
    4. Discuss the wise use of leisure time.
    5. Discuss the relationships between human resources and other natural resources.
    6. Should our population level be controlled?
    7. What are the social and moral implications of "the pill"?
    8. Is birth control desirable? Necessary?
    9. Should family size be regulated by factors such as income? Intelligence?
    10. Should a retired person work part-time?
    11. Should workers be retired at age sixty? Sixty-five? When?
    12. What are the common causes of death today? One hundred years ago?
    13. Is the percentage of mental patients increasing? Why?

14. Why are Thomas Malthus and Margaret Sanger remembered?
15. What percentage of food raised by man is deprived him by competitors? How?
16. Why will "overcrowding" hamper man in his struggle with competitors?
17. How has air and water pollution affected man's development?
18. Why are nervous disorders more common today than one hundred years ago?
19. Should hospitalization insurance be compulsory?
20. How has air and water pollution affected man's development of certain geographical areas?
21. How do the experiments of Urey and Miller provide some support for the hypothesis of the chemical origin of life?
22. How is it possible for the fossil remains of salt-water organisms to be found many miles from any ocean?
23. How do you explain the fact that many plants and animals found in England and Japan resemble each other more than plants and animals found in Africa and Madagascar.
24. Why are more bacteria and insects resistant to antibiotics and insecticides today than in 1950?
25. Discuss: Every living organism is descended from another living organism.
26. Discuss how the process of natural selection causes some species to become extinct.

D. Bulletin board displays.
   1. Safety in the home and industry.
   2. How various levels of government help to conserve human resources.
   3. Examples of wasting human resources, such as traffic accidents, mental hospitals, etc.
   4. Graphs showing the average wages of workers according to the number of years of schooling.
   5. Graph to show the average wage of various crafts and professions.
   6. Graph to show world population trends over the past two thousand years.
   7. Map of the United States to show the populations of the fifty states.
   8. World map to show the areas of greatest population densities (correlate with pollution areas).
   9. Chart or graph to show the causes of death today and one hundred years ago.

E. Student activities and projects.
   1. Write a paper on:
      a. Automation.
      b. "Population explosion".
      c. Proper use of leisure time.
      d. Problems of the aged.

    - e. Mental health.
    - f. Diseases and health programs.
  - 2. Form a group to improve a recreation area in your community.
  - 3. Conduct a survey of traffic and other hazards in your community. List methods of solving the problems.
  - 4. Gather information concerning the population increase as far back as you can. Predict the population to the year 2000. What factors must be taken into consideration in predicting future populations?
  - 5. Explain the long neck of the giraffe according to Mamarck, to Darwin, and to modern theory.
  - 6. Who is really responsible for pollution and why?

II. Learning Materials

- A. Audio-visual materials.
  - 1. See list of sources at the end of the guide.
- B. Books and pamphlets.
  - 1. Adams, J. A. S., "Man in Geologic Prospective", Chapter 16, Fundamentals of Geology, Harper & Row, 1966.
  - 2. Almanac and Yearbook, Reader's Digest Association, Pleasantville, New York, 1968.
  - 3. Bates, M., Man In Nature, Prentice-Hall, 1964.
  - 4. Bowen, W. G. (editor), Labor and the National Economy, W. W. Norton, 1965.
  - 5. Brown, H., The Challenge of Man's Future, Viking Press, 1956.
  - 6. Bresler, J. B. (editor), Human Ecology, Addison-Wesley, 1966.
  - 7. Coyle, D. C., Conservation, An American Story of Conflict and Accomplishment, Rutgers University Press, 1957.
  - 8. Davis, K., "Population", Scientific American, September, 1963.
  - 9. Deevey, E. S. Jr., "Radiocarbon Dating", Scientific American, February, 1962.
  - 10. Ehrlich, P. R., Population, Food, and Environment: Is the Battle Lost?, abstracts from a symposium at the University of Texas, 1967.
  - 11. Finch, Trewartha, and Shearer, The Earth and Its Resources, McGraw-Hill Book Company, 1941.
  - 12. Ginzberg, E. (editor), Technology and Social Change, Columbia University Press, 1964.
  - 13. Hardin, Garrett (editor), Population, Evolution, Birth Control, W. H. Freeman & Company, San Francisco.
  - 14. Howells, William H., "Homo Erectus", Scientific American, November, 1966.
  - 15. Hunker, H. L., Introduction to World Resources, Harper & Row, 1964.
  - 16. Jarrett, H. (editor), Perspectives on Conservation, The Johns Hopkins Press, 1958.

17. Kahn, H. and Wiener, A. J., The Year 2000, A Framework for Speculation on the Next Thirty-three Years, MacMillan Company, New York, 1967.

18. LaMont, Cole, "Man's Ecosystem", Bioscience, April, 1966.

19. Landsberg, H., Natural Resources for U. S. Growth, John Hopkins, 1964.

20. Marquis, R. W. (editor), Environmental Improvement, U. S. Department of Agriculture, 1966.

21. McAlester, A., The History of Life, Prentice-Hall, Inc., 1968.

22. Mudd, S. (editor), The Population Crisis and the Use of World Resources, Indiana University Press, 1964.

23. Odum, E. and Odum, R., Fundamentals of Animal Ecology, Saunders Press, 1960.

24. Osborn, F. (editor), Our Crowded Planet: Essays on the Pressures of Population, Doubleday & Company, Inc., 1962.

25. Simons, E. L., "The Early Relatives of Man", Scientific American, July, 1964.

26. Revelle, R., "Population", Science Journal, October, 1967.

27. Smith, Guy Harold, Conservation of Natural Resources, 3rd Edition, John Wiley & Sons, 1958.

28. "The People Explosion", The Christian Science Monitor, p. 9, March 18, 1968.

29. Weckler, Joseph, "Neanderthal Man", Scientific American, December, 1957.

FREE
AND
INEXPENSIVE
MATERIALS

Specific film titles were not listed because they tend to become outdated. Instead, four possible sources of films are given.

1. Contact local Regional Instructional Materials Center and request film catalogue.
2. Contact the audio-visual library of a local college or university.
3. Educators Guide to Free Films
   Educators Progress Service
   Randolph, Wisconsin 53956
   Request: Catalogue (small fee for catalogue)
4. Motion Picture Library
   U.S.D.A. - Soil Conservation Service
   7600 West Chester Pike
   Upper Darby, Pennsylvania 19082
   Request: Soil and water conservation films

The following list is a source of teaching materials related to conservation and ecology. Most of the material is free or available at a minimum cost.

1. American Forest Products, Inc.
   1835 K Street, N. W.
   Washington, D. C. 20006
   Request: Free forestry teaching materials
2. American Geological Institute
   2101 Constitution Avenue, N. W.
   Washington 25, D. C.
   Request: "Directory of Geoscience Films"
   (NAS-NRC #559)
3. Commonwealth of Pennsylvania
   Department of Internal Affairs
   Topographic and Geological Survey
   Harrisburg, Pennsylvania
   Request: Sample Rock and Mineral Kit of Pennsylvania; Information Circular #58, "Ground Water"; Educational Series Pamphlets Series 2, 4, 5, and 6; "Earth Science Teaching Aids"; "Earth Science Field Trip Guide Book"; "Common Rocks and Minerals of Pennsylvania"

4. Educational Book Division
   Prentice-Hall, Inc.
   Englewood Cliffs, New Jersey 07632
   Request: "Free Materials for Earth Science
   Teachers" (ESCP Pamphlet, Reference
   Series RS-5)
5. Federal Water Pollution Control Administration
   Washington, D. C. 20203
   Request: Pamphlet #WP-7
6. National Audubon Society
   1130 Fifth Avenue
   New York, New York 10028
   Request: Conservation films and pamphlet lists
7. Pennsylvania Department of Forests & Waters
   Robert G. Miller
   Public Relations Office
   510 Education Building
   Harrisburg, Pennsylvania 17120
   Request: "Common Trees of Pennsylvania" as
   well as other conservation and forestry material
8. Pennsylvania Department of Health
   Public Relations Section
   Room 1013
   Health and Welfare Building
   P.O. Box 90
   Harrisburg, Pennsylvania 17120
   Request: List of water and air pollution films;
   Pamphlets #HSE-6038P, 6527P; "So You Want
   to Know About . . . Clean Streams"; Newsletter,
   "Clean Air"
9. The American Museum of Natural History
   Central Park West at 79th Street
   New York, New York 10024
   Request: Catalogue of color slides
10. The Garden Club of America
    Conservation Committee
    598 Madison Avenue
    New York, New York 10022
    Request: Conservation material

11. The Pennsylvania State University
College of Agriculture, Extension Service
University Park, Pennsylvania 16802
Request: Circular #518

12. U. S. Department of Agriculture
Soil Conservation Service
100 North Cameron Street
Harrisburg, Pennsylvania
Request: List of Soil Conservation Service publications and films, SCS-TP-147, PA-337, PA-664, PA-629; Agriculture Information Bulletins, #99, #305, #244, #233, #175; miscellaneous publications, #925, #449; Farmer's Bulletins #2171, #1981, #2035, #2002; leaflets, #491, #458

13. U. S. Department of Health, Education, and Welfare
Public Health Service
Office of Education
Washington 25, D. C.
Request: Pamphlet #958

14. Pennsylvania Fish Commission
Public Relations Division
South Office Building
Harrisburg, Pennsylvania 17120
Request: List of available teaching materials; fishing, boating, and fly tying courses are also available (contact Mr. George Forrest)

15. Pennsylvania Game Commission
P.O. Box 1567
Harrisburg, Pennsylvania 17120
Request: List of available teaching materials; hunter safety course also available (contact Mr. John Behel)

16. Soil Conservation Society of America
7515 N. E. Ankeny Road
Ankeny, Iowa 50021
Request: Booklet, "Making a Home for Wildlife on the Land"

17. State Soil & Water Conservation Commission
2301 North Cameron Street
Harrisburg, Pennsylvania
Request: "Outstanding Conservation Films" by
Pennsylvania Association of Soil Conservation
District Directors

18. U. S. Geological Survey
Washington, D. C. 20242
Request: List of conservation and earth space
materials; Circular #532

19. U. S. Department of the Interior
Federal Water Pollution Control Administration
633 Indiana Avenue, N. W.
Washington, D. C. 20242
Request: List of films and pamphlets

20. Weyerhaeuser Company
P.O. Box A-74
Tacoma Building
Tacoma, Washington 98401
Request: "Sources of Information About Forest
Resources"

21. Wildlife Management Institute
Wire Building
Washington 5, D. C.
Request: "The Farmer and Wildlife"